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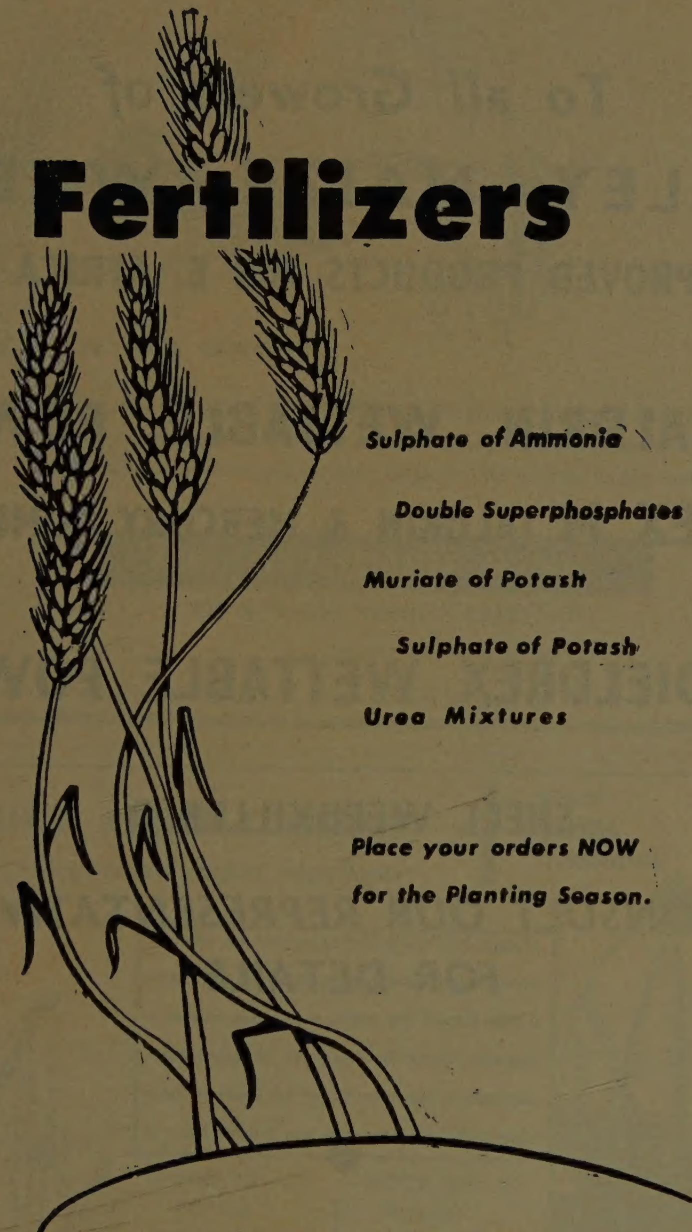

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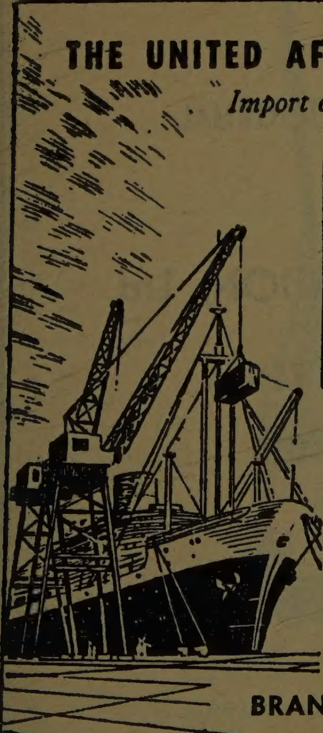

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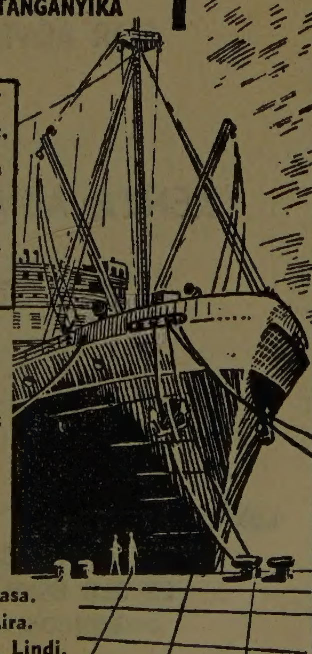

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Readers are reminded that all agricultural enquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

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NOTES ON KENYA AGRICULTURE

V—PLANTATION CROPS

Crop	Spacing	Plants per acre	Yield per acre	Time from Sowing to first Harvest
Arabica Coffee	9′ x 9′	536	8–15 cwt.	3½ years.
Robusta Coffee	12′ x 12′	302	9–18 cwt.	4½ years.
Cashew Nut	50′ x 50′	16	8–10 cwt.	3 years.
Clove	20′ x 20′	108	6–8 cwt.	9–12 years.
Coconut	28′ x 28′	55	7 cwt.	8–10 years.
Cotton	3′ x 2′	7,260	600–1,200 lb. (Seed cotton)	6–9 months.
Kenaf (Hibiscus)	8″ x 2″	—	1,500–2,000 lb.	3–4 months.
Kapok	18′ x 18′	134	800 lb. (floss)	3–4 years.
Pyrethrum	3′ x 1′ x 1′	21,000	400–1,000 lb.	4–6 months.
Sisal	13′ x 3′ x 2½′	2,000	3–5 tons (full cycle)	3–4 years.
Sugar Cane	4–6′ x 1′	7,260	25–45 tons (Cane)	14–18 months.
Tea	5′ x 2½′	3,485	4,500–5,500 lb. (fresh leaf)	5–7 years.
Tobacco	44″ x 22″	6,340	700–800 lb.	16–18 weeks
	36″ x 36″	4,840		

ARABICA COFFEE

By B. F. Hanger, Department of Agriculture, Kenya

Coffea arabica Kiswahili—Kahawa

Climate and Soils

Rainfall.—35-80 in. annually, depending on the varieties grown. Should be well distributed with short dry seasons. With prolonged dry seasons irrigation is essential.

Temperature.—Optimum — day maximum 88° F., night minimum 50° F. Over 90° F. repeatedly, produces soft, succulent growth with long internodes. Below 50° F.—short internodes, crinkled brittle leaves—"Hot and Cold" disease. Shade reduces diurnal temperature variation.

Altitude.—Limits:—

East Rift—4,500-6,200 ft.

West Rift—4,500-6,800 ft.

Hail.—Widespread occurrence in Nyanza Province. Protect by:—

(*a*) Temporary shade after planting of *Sesbania punctata*—9 ft. × 9 ft. planting.

(*b*) Permanent shade—*Cordia holstii* or *Erythrina indica* 18 ft. × 18 ft. planting.

Thinned at intervals to maintain stippled shade canopy.

Soils.—Free draining loam, no stones or murram, with good crumb structure. Kikuyu Red Loam is ideal. Depth 5-10 ft., dependent on rainfall and distribution. Slight to medium acidity increasing with depth. Readily available phosphate, especially during early stages.

Propagation and Establishment

The Seed.—Only seed from selected mother trees (i.e. clonal trees raised by vegetative propagation) should be used. Clonal seed supplies are available from Coffee Research Station, Ruiru. Seed taken from seedling trees produces sizeable minority of inferior plants. Sow seed immediately it is available to avoid decline in viability. Seed should have moisture content of 15-18 per cent.

Selection of Nursery Sites.—Site on flat or even gentle slope, near a perennial water supply, but not in a hollow where cold air settles. If slope exceeds 4-5 per cent, bench terrace.

Soil.—Light or medium loam, minimum depth of three feet. Take care to maintain even spread of top soil if bench terracing performed. Choose sheltered site, but remove large trees in immediate vicinity of nursery as seedlings suffer from competition. Growth of seedlings will be slow at higher altitudes.

Preparation of Seedling Beds.—Beds from 3-5 ft. wide and any convenient length. Construct in east-west direction across the slope. Dig beds in dry weather to depth of 2 ft., incorporating liberal supply farmyard manure or compost. Raise soil in beds 6 inches above path level. Add superphosphate—1 oz. per square yard. Protect seedlings against direct sunlight by use of fencing posts 36-39 in. high at 10 ft. intervals as support for strained wire on either side of bed. Split sisal poles or bamboos placed across wires form ideal adjustable shade.

Seed Sowing.—Sow in drills 6-8 in. apart, with 2-3 lines of seed/drill. Cover seed with ½ in. fine soil and 1 in. mulch of dry short grass. Provide dense shade to prevent surface soil packing and drying out. Water to maintain topsoil in moist condition. After germination, in eight weeks, remove mulching material.

Transplanting.—Transplant when first pair true leaves fully formed. Reject all substandard seedlings with poor root systems. Use wooden planting board, notched at 8 in. intervals, to plant on square at 8 in. × 8 in. (6 in. × 6 in. may be used where growth is rapid.) Thoroughly wet seedling and pricking out beds before transplanting. Lift seedlings by hand fork into damp sacking. Take care that the tap root is not bent during planting. Stand on a board to avoid over-consolidation of pricking out bed. Mulch with fine grass and fully shade immediately after transplanting. Wet soil to full depth of root range, ensure bed does not dry out.

Regulation of Shade.—Remove shade gradually, starting in second month after transplanting until all shade removed and plants fully hardened.

Transfer and Establishment of Plants in the Field.—Prepare planting holes at spacing of 9 ft. × 9 ft, at least two months before transplanting. Holes should be square and occupy at least 8 cubic feet, i.e. 2 × 2 × 2. Lay topsoil aside separately, incorporate 1-1½ 4-gallon tins good manure to 8-cubic ft. hole or 2-3 tins to 27-cubic ft. hole, i.e. 3 ft. × 3 ft. × 3ft. If cattle manure unavailable use ¼-½ lb. basic slag.

Add 2 oz. double superphosphate when refilling hole, and replace topsoil at the top of the hole.

For transplanting stems of plants should be pencil thick—may be smaller in heavy rainfall districts and should be larger for drier areas. Cap seedlings down to 10-15 in. 2-3 weeks before transplanting. Transplant 1-2 weeks after start of main rains, preferably on a dull day. Lift plants from wet nursery beds, avoiding damage to roots and transport in wet sacking or grass.

Replant without delay, placing roots carefully and firming soil well. Avoid twisting tap root.

Mulch with 4 in. of Napier grass and shade plants from sun. Three weeks after planting apply 2 oz. of sulphate of ammonia within root range but at least 3 in. from trunk of tree.

Annual manuring for three years following planting:—

(*a*) Two tins cattle manure mulched over root range of tree before start of the main rains followed by

(*b*) two to four oz. sulphate of ammonia to root range three weeks after start of main rains. (One to 3 oz. of urea may be substituted two years after planting.)

Fifteen months after planting:—

(*a*) Prune off lower primaries leaving a "breather primary" or lung branch 21 in. from ground on one leader and the above remaining primaries.

(*b*) Shorten breather to 18 in.

(*c*) Remove secondary growths as they appear.

Do not crop the tree until at least 2½ years from planting.

Cultural Practice (Established Coffee)

Pruning.—Prune immediately after harvesting. Remove primaries to leave a 3-4 ft. head, i.e. 3 ft. in fast-growing conditions, 4 ft. in high altitude zones. Remove secondary shoots until last flowering of crop season, then leave one or two pairs non-fruiting secondaries to increase leaf/crop ratio. Remove all sucker growth on leaders and main bole until 5-8 years from planting when young suckers are selected for the next cycle.

To Change Cycle.—(*a*) Remove primaries to leave 2 ft. head immediately after harvesting. (*b*) Select three suitably spaced suckers 10-20 in. from the ground to provide leaders for new cycle. Suckers with internodes of more than 4 in. are unsuitable. (*c*) Take a crop off the reduced head and then cut off to above new leaders or breather primary.

Mulching.—Under optimum conditions allow ½ acre Napier grass (*Pennisetum purpureum*) to mulch 1 acre coffee. Increase area of grass under less favourable conditions. Complete mulch, about 4 in. thick, prior to main rains.

Cultivation.—Remove all weeds regularly; weed growth should be small if mulching has been adequate. Shallow cultivation (3 in. deep) with fork hoe prior to pre-rains mulching.

Fertilizers.—Three weeks after start of main rains 3 oz. urea should be broadcast around each tree in a band 2-4 ft. from the base.

Harvesting and Factory Treatment

Aim at uniform pick of cherry-red colour. (Over-ripe cherry preferable to under-ripe if optimum unattainable.) If a high percentage of Coffee Berry Disease, cherry should be picked and processed separately. Process immediately after picking to avoid decomposition of cherry skins. Avoid overnight processing by installation of more pulpers.

Depulping.—Even flow of cherry to pulper essential. If pulper set too fine—cherries "nipped"; if set too wide—pulping defective.

Grading.—Use Aagaard Sieve, Rotatory Screen or Shaker Sieve. Rotatory Screen and Shaker Sieve necessitate further grading in pre-washing channels.

Fermentation.—Mucilage surrounding fermenting beans should be clear. Daily washing if water is available. Duration—42-72 hours dependent on temperature conditions (i.e. altitude). Fermenting tanks should be covered to avoid drying out of surface beans. When there is no trace of adhering mucilages coffee is ready for final washing. In final washing—meticulous care must be taken to clean parchment completely.

Sun-drying.—Tables 4 ft. wide—parchment laid to depth up to 2 in. In very fine sunny weather cover coffee 12 noon to 3 p.m. to aviod damage to bean and parchment. Under cloudy conditions—exposure throughout hours of daylight. Turn parchment frequently during drying. Avoid rewetting by rain, especially during latter stages. Colour changes during drying:

	Per cent moisture content
White stage	54=fully wet
Skin dry	42 approximately
Opaque	30 approximately
Soft black stage ..	25 approximately
Hard black stage ..	18 approximately
Green blue	11=finished

Green blue stage—coffee sacked, transported to mills or stored in cool, well ventilated store.

ROBUSTA COFFEE

By A. H. Savile and B. Hanger, Department of Agriculture, Kenya

Coffea canophora Kiswahili—Kahawa

Climate and Soils

Requires a more evenly distributed rainfall than arabica coffee and prefers a narrower temperature range—58° F. to 85° F. approximately, with an altitude range of 3,500 to 5,000 ft. under East African conditions.

In Uganda the criteria for successful robusta cultivation are an annual rainfall of 42-70 in. with over 3 in. monthly rainfall during 10 months of the year. The Robusta coffee tree is intolerant of prolonged dry periods and exposure to drying winds, it requires greater humidity and warmer temperatures than arabica coffee. soils should be deep, fertile, well-drained but retentive of moisture, and neutral or slightly acid in reaction. In Kenya the indications are that robusta coffee may grow well at an altitude of below 4,500 ft. in Nyanza Province. Robusta will not succeed where it is subjected to a wide range of climatic conditions.

Cultivation

There are two tree types—spreading and erect. The spreading type, planted at 15 ft. × 15 ft., achieves complete ground cover after about 12 years, thus suppressing weed growth, but the crop is difficult to pick and of inferior quality. The erect type is preferred to the spreading type because it produces higher yields of better quality and is easy to harvest; plant at 10 ft. × 10 ft. It should be grown on a multiple stem system similar to arabica. Capping of the trees in the nursery prior to planting will produce two strong heads for the first cycle, in succeeding cycles four or five

leaders should be selected from the bole of the tree. The primaries which have borne heavily should be pruned off after cropping. Young seedlings are more difficult to establish than arabica coffee and have a root system with more surface roots than arabica coffee. The initial growth made by robusta coffee under Nyanza conditions is slower than that made by arabica coffee. Shade is recommended, but good coffee can be grown around Masaka in Uganda without shade, due to the frequent absence of morning sun because of high cloud cover. In the Nyanza Province and in other parts of Uganda shade is either beneficial or essential in creating a microclimate. Bananas should not be interplanted with robusta because of competition for soil moisture but may be used as a windbreak around the sides of the coffee plot. Shade trees recommended are *Albizia stipulata, Cordia holstii*, and *Erythrina* sp. *Ficus natalensis* is widely planted in Uganda but is not recommended in low rainfall areas. In mature plantations avoid damage by cultivation to surface feeding roots by suppressing weeds with a heavy mulch of grass, banana trash, coffee husks or cotton seed husks. The application of farmyard manure within the root run of the tree is very beneficial.

Harvesting

Although almost the entire Uganda crop is sun-dried there is a price premium for washed robusta coffee of between 15 and 20 per cent over the average price for sun-dried robusta. The pulping and fermentation process is the same as for arabica coffee. Sun-dry the crop on raised trays, which can be moved under cover at night or during rain. Yields after hulling should be from 7 to 14 cwt. of clean coffee per acre.

Major Uses

For blending with milder coffees, coffee essence and powdered extracts.

CASHEW-NUT

By A. H. Savile and R. H. Bennison, Department of Agriculture, Kenya

Anacardium occidentale

Kiswahili—tree Mkanju; fruit Korosho

Climate and Soils

Rainfall 25 in. and over. In higher rainfall areas a dry period from flowering to harvest is necessary for heavy crop and sound nuts.

Cultivation

Plant at stake in well prepared sites as seedlings will not stand transplanting. Planting at 50 ft. × 50 ft. = 16 trees per acre. Keep free from weed competition. In Tanganyika it has been demonstrated that early and clean-weeding of cashew plantations results in markedly increased yields largely owing to the resultant absence of *Helopeltis*.

Harvesting

Nuts should be allowed to mature on the tree and drop to the ground. If heavy rain is experienced during harvesting, immature nuts will fall. These can be detected by a softness of the shell and flattening of the lower end of the nut. These must be discarded as they dry badly, cause heating and will not shell out whole. Mature nuts should be collected daily and separated from the fleshy stalk before drying. Nuts should be sun dried for at least two days until kernels rattle when shaken. Sound dry nuts should *not* be stored together with defective or damp nuts. Yields—7 lb. raw nuts per tree at three years up to 70 lb. for 15-year old trees. Yields might be increased by closer spacing.

Major Uses

The nuts are a popular delicacy. The oil contained in the husk has commercial value in preventing fade in brake linings.

CLOVE

By A. H. Savile and R. H. Bennison, Department of Agriculture, Kenya

Eugenia caryophyllata Kiswahili—Karafuu

Climate and Soils

Usually grown at sea level but occasionally as high as 2,500 ft. above sea level. Avoid sites exposed to strong sea breezes. Requires 60 in.-80 in. rainfall. Soil should be deep, rich clay loam or sandy loam free from water-logging. The plant will not thrive on clays or sands, and marshy soils are fatal.

Cultivation

Propagated by seed which must be fresh. Germination period five-six weeks. Seedlings, which grow very slowly, may be planted out when 15 in.-18 in. high. Seedlings must be grown under shade in nursery and protected from strong sun for a considerable period after transplanting. In the Moluccas banana shade is provided for first two-three years. Planting holes at 20 ft. × 20 ft. = 108 trees per acre. Leave holes open for several weeks before refilling with mixture of surface soil, cattle manure and rubbish, leaves, etc. Take great care to avoid damaging roots of seedlings when transplanting. Transplant at onset of long rains. After transplanting seedlings should be well-watered at least weekly during dry weather until established. Trees start bearing when 9-12 years old and are in full bearing when 20 years old.

Harvesting

Starts when flower buds start turning red. Clusters are removed by hand, crooked stick, or gentle beating. Injury to tree during harvesting will reduce following crop. Cloths should be spread to catch cloves during harvesting. Yields vary considerably from year to year but average of six-eight lb. of dried cloves per tree should be obtained. Harvested cloves are sun-dried and lose 60 per cent weight during process. Care must be taken to ensure cured cloves are kept dry to prevent subsequent deterioration.

Major Uses

Essential oil is distilled containing 85-95 per cent eugenol, used in manufacture of synthetic vanillin, perfumery and medicine.

COCONUT

By A. H. Savile and R. H. Bennison, Department of Agriculture, Kenya

Cocos nucifera Kiswahili—Mnazi

Ecological Conditions

Prefers moist, hot climate at the coast but can be grown inland under conditions of high temperature and rainfall—40 in. and over. Soils—Heavy, free-draining loams or alluvial soils best but will also grow on light coastal sands though yields are then lower.

Cultivation

Propagation by nuts sown in the husk, in nurseries. Germination in three months. Ready for planting out at 9-12 months. Planting distance 28 ft. × 28 ft. = 55 palms per acre. Beforehand, dig holes 3 ft. × 3 ft. which should remain open for a month or two. Then fill in with top soil mixed with compost or well-rotted manure, and plant germinated nuts when rains have broken. The land should be kept free from weeds, grass and bush, but may be inter-cropped with non-greedy feeders such as cowpea and pigeon pea. When palms are over six ft. tall, cassava can be grown without ill effect and on old plantations it has resulted in increased yields. The palm starts bearing at eight-ten years, full bearing at 15 years, normal life 60 years.

Harvesting

Best results are produced when fallen nuts only are collected. This method is also cheaper than when pickers are employed to climb the palms and cut down mature nuts. Nuts should then be stored for one-two months before being turned into copra. Common practice is to remove the husk then split the nut, but the cheapest way is to split open the unhusked nut with a single blow of a sharp axe. Thereafter the nut is sun-dried for one-two days until the flesh can be removed from the nut. The drying process is

then completed in the sun or in a kiln, the heat being supplied by a slow fire of coconut shells, care being taken to prevent scorching of the copra. When copra is dried in the sun, care is needed to prevent damage from rain and dew. Yields per palm vary from 10 to 120 nuts per year but should average 30-45 nuts on good plantations. Picking of immature nuts has an adverse effect on nut production. Under local conditions 90-120 nuts are required to produce one frasila (36 lb.) of copra. At 62½ frasilas to one ton—say 5,600 to 7,500 nuts to produce one ton of copra. Roughly one palm should produce one-third frasila of copra, i.e. three acres to produce one ton of copra.

Major Uses

Dried flesh (endocarp) of the nut is known as copra which yields valuable oil used in cookery and making soap, margarine, etc. The residue after expressing the oil is a valuable cattle cake or fertilizer. The husk (pericarp), after retting in water for about a month, yields coir fibre. Desiccated coconut for the confectionery trade is prepared from fresh nuts.

COTTON

By the Empire Cotton Growing Corporation, Namulonge, Uganda

Gossypium hirsutum Kiswahili—Pamba

The principal cotton growing areas of Kenya are the Coast and Nyanza Provinces. The variety grown at the Coast is UK.51 and, in Nyanza, S.47 is grown in Central and Elgon Nyanza, and UK.51 in South Nyanza. Both varieties are what is known as American Upland cotton.

Climate and Soils

Shade temperatures in the cotton areas during the season seldom fall below 65° F. Rainfall is usually in excess of 30 in., a large proportion of which falls during April and May. The distribution of rainfall shows, generally, two main peaks. The first and largest occurs during April and May, and the other in September to November. The latter is not very reliable at the Coast and in many parts of the Nyanza Province and, therefore, cotton crops should be planted in time to benefit from the main rains of April and May. In Nyanza, cotton grows best below 4,000 ft.

The soil types found in the cotton areas vary from the light, highly pervious sands found at the Coast, to the heavy clays of part of the Lake Shore area of Nyanza.

While cotton will grow in a fairly wide range of soil types it will also tolerate quite a large range of pH. Values of pH 6-7 are considered best suited for cotton growing.

Cultivation

Cotton is grown as an annual and takes from six-nine months to produce its crop. At the Coast, cotton is usually intercropped with maize and sometimes with cassava or simsim. This system should not be encouraged and efforts are being made to get growers to plant their cotton as pure stands as is done in Nyanza. In some Districts of Nyanza beans are often planted between the cotton rows during the short rains. The cotton crop is grown almost entirely by African peasants. At the Coast there are some Arab farmers who grow cotton.

	Planting Period	Picking Period	Uprooting Date
Coast Province ..	mid April–mid June	October–mid Jan.	mid February
Nyanza Province..	April–July	Sept.–March	March

Preparation.—Common to open new land for cotton planting. Land should be ready for planting in March or April. It is usual for growers to plant on flat but the use of tied ridges have been found beneficial in some areas to hold up storm water and allow it time to percolate into the soil.

Planting.—Planting should be done at the break of the main rains. Spacing recommended to growers is rows 3 ft. apart, holes 2 ft. apart in row, five seeds per hole. Holes are about 2 in. deep.

Thinning.—Plants are thinned to two per hole at two-three weeks after planting.

Inter-cultivation.—As often as necessary to control weeds and repair ridges where used.

Harvesting

Cotton in Kenya does not produce large flushes of open bolls over short periods. Instead, bolls open over a fairly long period of time and hence harvesting operations are somewhat protracted.

It is imperative that the cotton locks should be dry and picked frequently as lint deteriorates with sunlight, rain and dust, apart from falling on the ground. Picking should be done with two baskets using one for "A" grade (unstained) and another for "B" grade (stained). The baskets may be joined together and hung round the neck or used independently, first picking "A" grade and then going round a second time with the other basket to pick "B" grade. Use of these methods obviates having to pick over the crop which is time-consuming and tedious and results usually in poor "A" grade.

Both grades should be stored separately in a clean dry place and sold as soon as possible to the ginnery.

Uprooting and Close Season

Due to the numerous pests and diseases which afflict the cotton crop a regime whereby cotton plants are uprooted and burned after harvesting is enforced by the Agricultural Department. Although an effort is made to have a close season the late planted crop is late maturing and the uprooting date is consequently delayed and so reduces the period between the removal of one crop and the first plantings of the next.

Major Uses

There are five products obtained from seed cotton. They are lint, linters (fuzz), seed kernel, hull (seed coat) and waste. The latter two have no commercial value. Unstained (Grade "A") lint has numerous uses including fabrics for wearing apparel and domestic uses, threads, string, fishing lines, canvas for tents, belting, hosepipes, carpets, typewriter ribbons, laces, gauzes, towelling, etc. Stained (Grade "B") lint is used in upholstery, cushions, mattresses, absorbent cottonwool. Linters is used for mattresses and upholstery and is the purest base for alpha-cellulose which is used in the production of high tenacity rayon, explosives, X-ray photographic films, shatter-proof glass, plastics, and other cellulose products.

The seed kernel consists of 16-20 per cent protein and about 18 per cent oil. The oil is one of the world's most important semi-drying oils, and is used for culinary purposes, margarine, lard compounds, paint, lubricants and soap. The cake can be fed to cattle but not other livestock owing to the presence of gossypol. It can also be used as a fertilizer, having up to five per cent nitrogen.

KENAF

By W. A. Wright, Department of Agriculture, Kenya

Hibiscus cannibinus

Climate and Soils

A rainfall of not less than 20-25 in. over a period of three to four months is essential. A very heavy rainfall is detrimental. Best results in Kenya have been obtained under irrigation. Kenaf cannot tolerate any hint of waterlogging when grown as a crop. The range of temperature in which it grows satisfactorily is between 55° and 85°, the best temperatures being those in the middle of this range. It does not do well in regions where nights are cool. A well-drained sandy loam with a neutral reaction is the best type of soil. It should also be well supplied with humus. Light, sandy soils are not recommended as the plants remain short, bloom early and give low fibre yields. Heavy soils are equally unsatisfactory, mainly because of the plant's sensitivity to waterlogging under cultivation.

Cultivation

Thorough soil preparation is necessary in order to obtain uniform germination and even stand so that stalks may be of uniform size at harvest. The seed is sown in rows 8 in. apart at the rate of 20 to 30 lb. per acre, the higher rate being recommended for fertile soil with

an abundance of moisture. Thinning is subsequently done to leave plants 2 in. apart in the rows. (Wider spacing both within and between rows is practised where the object is seed production rather than fibre.) On most soils commercial fertilizers are required for best growth, phosphate and nitrogen being the important elements to supply in Kenya.

Harvesting

The best quality of fibre is obtained by harvesting the plants during the early flowering period but, by delaying cutting until two-thirds of the flowering is completed, higher fibre yields are obtained. The period to maturity varies with varieties but is generally from about 90 to 100 days for best quality fibre and up to 130 days for highest yields. The plants are usually cut by hand as near ground-level as possible, tied into bundles and the tops, where the majority of leaves are, cut off. Harvesting is now being done to an increasing extent mechanically and efforts to produce a satisfactory harvester-ribboner are advanced.

Fibre Extraction

In the past fibre extraction has been done by hand. After drying the bundles for two or three days they were submerged in water and retted from five to as much as 22 days, depending on retting conditions, mainly temperature. Fibre was then stripped and cleaned by hand. Much progress has now been made with mechanical processing. There are, in general, two methods as follows:—(1) the fibre is ribboned, i.e. roughly separated from the stem immediately after harvesting, and these ribbons are decorticated on a machine which cleans the bark from the fibres, and (2) ribboning, as stated above, followed by retting of these ribbons in water to release the bark. In the past, decorticated fibre has not been popular with spinners but there is considerable difference of opinion on the point.

Yields of Fibre

Yields of 2,000 lb. per acre or greater have frequently been reported, but 1,500 lb. per acre might be a better estimate for soils normally selected for this crop.

KAPOK

By A. H. Savile, Department of Agriculture, Kenya

Eriodendron anfractuosum Kiswahili—Sufi

Climate and Soils

Will grow from sea-level to elevations of 2,500 ft. or more, but best results are obtained at low and intermediate elevations below 1,500 ft. Kapok flourishes under a wide range of conditions. It is able to withstand a long period of drought; but the ideal conditions are abundant rain during the growing season, and a dry period from the time the flowers set until the pods are harvested. A long spell of wet or even damp weather during the latter stages of pod formation will reduce the quantity of the fibre. Exposed situations are not suitable, as the branches which are quick growing are liable to be easily broken or damaged by high winds.

The best soil is a deep, porous, sandy loam which is well drained; kapok will not thrive on a heavy soil which tends to remain wet. Since a high crop yield is required, the soil should be of a fairly high degree of fertility.

Cultivation

May be propagated by seed or cuttings. Cuttings should be 1-2 in. in diameter and 4-6 ft. long, and older than the present year's growth. Large cuttings have been found to give better results than small ones. Cuttings should be planted in the field as soon as possible after they have been cut, and should be inserted 12-18 in. deep according to size.

Harvesting and Yields

The pods are collected as they drop, in a dry state, when the weather is fine. If it is damp or wet during the ripening period, the pods should be picked as they mature. Picking is carried out by severing the stalks by means of a knife attached to a long pole. As the pods ripen they change colour from light-green to light-brown. It is at this stage that the pods should be harvested before they open at both ends and expose the floss. The whole crop should not be harvested at once, as this will result in a mixture of pods of different degrees

of maturity, and consequently the floss will be of uneven quality.

After picking, the pods should be spread on a dry floor for a few days till they ripen thoroughly, and the floss should be removed as soon as possible. The average annual yield per tree and per acre from 134 trees, planted 18 ft. × 18 ft. may be expected to be as in Table I.

TABLE I

Age	No. of Pods per tree	Floss lb. per tree	Floss lb. per acre
3–4 years	100	1	134
5–6 years	200	2	268
7–8 years	400	4	536
10 years	600	6	804

The relative proportions of the different parts of the pods are:—

	Per cent		Per cent
Husk or shell ..	42	Cores ..	18
Seed	23	Floss ..	17

PREPARATION OF FLOSS

The initial process consists of the opening of the pods and removal of floss with the seed within from the core and the husk.

Various types of machine may be used to separate the seed from the floss. The work is often done in an ordinary cotton gin after the cotton season is over.

Owing to the bulky nature of the material, the floss is pressed into bales. Too much pressure must be avoided, especially with the finest quality, otherwise the elasticity of the fibre will be destroyed. Machine-cleaned very dry fibre requires more pressure than hand-cleaned but, on the average, the pressure should not exceed 140 lb. per sq. in.

The weight of the bales range from 80-120 lb. and the size from 8-16 cu. ft.

MAJOR USES

The chief uses for kapok are for stuffing cushions, pillows, mattresses, etc. It is well adapted for this purpose on account of its lightness, its springy or resilient nature, and its non-hygroscopic and non-absorbent characters. It is also largely employed in life-saving appliances.

PYRETHRUM

By U. Kroll. Department of Agriculture, Kenya

Pyrethrum cinerariaefolium

CLIMATE AND SOILS

Rainfall 35 inches to 70 inches. Although fairly tolerant towards soil type and acidity pyrethrum produces really satisfactory yields only on soils with a good fertility. It does well on virgin land provided a good tilth has been obtained. Soils must be well drained, since waterlogging causes death of plants. Crops following pyrethrum usually thrive, but soil structure should eventually be rebuilt, by rotation with a grass ley, before pyrethrum is planted again on the same land. Especially at the higher altitudes on reddish soils, where the effect of leaching is more pronounced, and on soils derived from the basement complex phosphatic dressings of from 150 to 200 lb./acre triple superphosphate or 275 to 500 lb./acre basic slag are recommended. As flowering is impeded when mean temperatures rise above a certain level the crop can be cultivated successfully at the colder levels only. The actual altitude varies according to the general aspect of the country, the proximity to forests or mountains, etc. In the Taita Hills, which constitute an exceptional case, pyrethrum could be grown from 5,000 feet upwards, while the lower limit east of the Rift Valley is probably 6,000 feet and west of the Rift, about 6,500 feet. In areas with a high rainfall (Kisii, Kericho) and consequently low mean temperatures, the critical altitude level is lower. Pyrethrins content generally is higher at colder localities.

CULTIVATION

Pyrethrum can be planted either in the form of splits (root divisions) or seedlings. Splits come into flower more quickly (about 3-4 months) but suffer more easily during the initial stages from drought, while seedlings which start producing 5-6 months after planting are more drought-resistant. If a new

variety is to be established, seed should be used. New material, reared in a clean nursery, is also desirable when old plantations become too heavily infested with root-knot eelworm. Seedlings have to be reared in a nursery and the following method is recommended:—

Choose site for nursery on good land in proximity to permanent water. If on slope prepare bench terraces. Prepare soil to good, fine tilth. Beds need not be raised. Beds about 4 feet wide so that weeding from either side is possible, with narrow paths between beds. Make shallow rills, $\frac{1}{4}$ to $\frac{1}{2}$ inch deep, with stick and dibble seed into these. One ounce of seed should cover 100 square feet of seed bed; this is achieved by dibbling approximately 10 seeds per inch in the row. Seed rows about 5 inches apart. Only a very light or no cover with soil should be given. Seed beds to be mulched with grass and well watered. Fairly heavy watering to be continued until most of the seed has germinated. Then protect with grass thatch raised on to trestles about 1 foot above ground and decrease watering slightly, but keep soil moist until seedlings are large enough to keep alive with moderate watering. A few weeks before planting into field remove grass thatch. Ready to plant out about 4-5 months after sowing. If pyrethrum is propagated by splitting, only vigorous plants should be selected and fairly large root divisions made with a good portion of the original root system. Woody splits must be avoided. The optimum number of plants per acre is about 21,000, but spacing will depend largely on method of planting and cultivation. If planting lines or ridges are marked out by tractor, single rows, 2 feet 4 inches to 3 feet apart with 1 foot between plants within rows are most practical, while in African areas, especially on steeper slopes, the double row system of 3′ × 1′ × 1′ can be recommended. Planting on ridges has often given yield increases, it also facilitates mechanical cultivation. Planting lines should follow contours. Whether planting holes are made by hand or furrows by mechanical means, careful planting and firming down of roots are most important. Good yields depend primarily on perfect stand and gapping-up is satisfactory only if carried out soon after original planting. Seedlings should not be planted too deeply as they might be smothered by silt in heavy storms or drowned.

Careful weeding is essential; between rows, mechanical cultivators or ridgers, if used with care, can deal with most weed growth, but cleaning by hand is indispensable around and in the plants. Chemical weed-control, for the time being, cannot be recommended. It is important to clean the land well of stoloniferous grasses (Blue Couch, *Digitaria scalarum*, Kikuyu Grass, *Pennisetum clandestinum* and Star Grass, *Cynodon Dactylon*, etc.) before pyrethrum is planted. These grasses cannot be dislodged later without uprooting the pyrethrum. A dangerous weed is Sorrel (*Oxalis* spp.) as it is apt to smother pyrethrum plants. For weeding within and near plants do not use fork hoes, but use small forks or pointed sticks.

On most soils, no fertilizers or manures have given responses but on certain soil types (*see* paragraph 1) dressings with superphosphate or basic slag are recommended. These are of benefit only if applied at planting time, either into the planting holes or into shallow furrows below the ridges. In most cases, yield increases have been observed over two and three seasons. Top dressing of established pyrethrum is quite ineffectual. Mulching between rows has given encouraging results only at the lower and warmer altitudes.

In Kenya, two or three months after cessation of rains flowering comes to an end. The old flower stalks should then be cut back down to foliage level; more severe cutting back might reduce yield in subsequent season.

Varieties for different altitude levels are being produced on the Pyrethrum Research Stations. The position is constantly changing as new hybrids are issued and advice should be sought from the Department of Agriculture.

Pyrethrum, although it does not exhaust the soil fertility, should not be kept longer in the ground than three or four seasons. Usually after three seasons the number of unavoidable gaps and of plants which have stopped flowering makes the plantation uneconomic. The structure of the surface soil has deteriorated, weeding becomes too expensive. Most crops, especially cereals, following pyrethrum produce good yields. But a grass ley should be inserted in the rotation to recondition the crumb structure and to reduce the eelworm population, which will take at least three years.

Harvesting

Unnecessary to pick flowers selectively; stripping of all flowers with horizontal petals

at intervals of from 14 to 21 days has produced as high or higher yield of pyrethrins per acre and required less supervision. Flowers must be picked without stalk. Interval between pickings will vary and will be shorter during heavy flushes and at slightly warmer localities. If proportion of over-mature (overblown) flowers rises above 10 per cent, loss in pyrethrins occurs.

It is advisable to start drying as soon after harvesting as possible. If dryer capacity insufficient, spread flowers on trays for wilting previous to drying. For design of dryer apply to Pyrethrum Board. Sun-drying is satisfactory only during dry weather, at lower altitudes and with relatively small quantities of flowers. Flowers lose about 75 per cent of their weight in drying. Do not keep flowers in storage for any length of time but despatch as soon as possible, to avoid losses in pyrethrins.

Yield per acre varies considerably according to altitude, soil and rainfall. At higher altitudes 800-1,000 lb. of dried flowers, decreasing to 300-400 lb. at lower limits.

Diseases and Pests

Severe loss in yield can be caused through a fungus, *Ramularia bellumensis*, which attacks buds or flowers. Direct control measures (spraying, etc.) have not been encouraging, but it appears that less vigorous plants and those suffering from unfavourable growing conditions will be more susceptible. Selection for vigour and disease-resistance is part of the breeding programme. Flowers and buds are attacked by other fungi as well (*Ascochyta, Alternaria*, etc.); all these diseases seem to be encouraged by long spells of rainy and sun-less weather. When splitting up material for new plantings avoid plants with a high percentage of bud disease as susceptibility is an inherent factor.

Root rot, which may be caused by several fungus species, usually occurs after plants have been weakened through waterlogging, eelworm, etc., or on very rich forest soils or sites of old cattle yards. It may be necessary to uproot pyrethrum and plant different crops for a few years. Do not use infected splits as planting material.

Root Knot Eelworm (*Meloidogyne* sp.) is a common parasite in pyrethrum; its presence can easily be discovered by swellings on the roots. Normally it appears to cause little harm, but in combination with waterlogging, poor soil conditions, drought, etc., it can become a serious pest. It is advised not to use infested plants for propagation and in order to reduce the nematode population, to rotate the land with grass leys.

Thrips (*Thrips tabaci*) seems to be always present in the pyrethrum flowers without being harmful. But under certain climatic conditions it multiplies and not only causes a deterioration of the flowers but destroys the foliage, which turns black, and often the whole plant does so too. Control by spraying with 25 per cent DDT emulsion (3 pints per acre in 30-100 gallons of water, to be repeated at 10-14 days intervals if necessary). Frost can cause die-back of buds. This occurs mainly in hollows and in certain parts of the Colony (Kinangop) especially during the dry season. Hail causes dark bruises on the flower centres and sometimes shedding of the white petals.

Major Uses

Pyrethrum is used solely as an insecticide. The toxic agents are contained mainly in the walls of the achenes and are freed through grinding of the flower and extraction. A certain quantity of dried flowers is exported in baled form but the aim of the industry is to sell the crop in the form of pyrethrum extract, thereby avoiding losses in transit.

For more detailed information consult *The Cultivation of Pyrethrum in Kenya*, published by the Pyrethrum Board.

SISAL

By K. Lerche, Department of Agriculture, Kenya

Agave sisalana Kiswahili—Mkonge

Climate and Soils

Thrives in a warm, humid climate, preferably at 0-2,000 ft. above sea-level, though it will grow satisfactorily at altitudes up to 6,000 ft. Rainfall, 25-50 in. Best yields obtained on fertile loams, but owing to its hardiness, often grown on poor soils where no other plantation crop can be produced. Waterlogged conditions must be avoided.

Cultivation

Thorough preparation of the land essential for satisfactory growth. On black cotton soils the land should be subsoiled and ridged. Couch grass must be controlled before planting. Sisal waste from the factory should be returned to the fields to maintain fertility.

Bulbils grown in nursery should be used for planting. Planting distance 2ft. × 9 in. or 29,040 bulbils per acre of nursery, previously manured with 30-50 tons of rotted sisal waste dug into topsoil. Bulbils ready to plant out at 24 in. after 15 to 18 months. Approximately 13 ft. is needed between sisal rows to facilitate cutting and tractor cultivation, etc. To obtain optimum population of 2,000 plants per acre it is necessary to plant in double rows, 3 ft. apart with plants staggered at 2 ft. 9 in. in the rows and 13 ft. between the double rows, giving 1,980 plants per acre. Clean weeding essential in the 3-ft. strip inter-row space, plus 2 ft. 6 in. on either side of the rows, leaving an 8-ft. strip between each pair of double rows which should not be clean-weeded but should be kept under a short growth of grass or cover crop, controlled to prevent undue competition for moisture.

Sisal can only be produced profitably where production is at least 1,000 tons of fibre per year. With a yield of say 3 tons in a ten-year cycle, this equals one-third ton per acre annually. Minimum acreage should therefore exceed 3,000 acres. The crop is unsuited to peasant production except as a means of utilizing sisal hedges to produce a subsidiary income in areas subject to immediate rainfall.

Harvesting

Only leaves of 2 ft. and over are harvested. First cut usually three to four years after transplanting when plants have produced 125 leaves and are 5 ft. high. 35-40 leaves should be left on the plant after first cut. As many as 50-60 leaves may be too short, leaving 25-30 leaves per plant to be cut. At this stage 100,000 to 120,000 leaves are required to produce 1 ton of fibre. Further cuts at yearly intervals yield 20-25 leaves per plant which, with increasing length and fibre content, result in a gradual reduction in number of leaves required per ton of fibre until final cuts need only about 35,000 leaves per ton of fibre. After plants have produced 250-280 leaves, which may take 10-12 years from planting in the field, poling takes place. From 2,000-4,000 bulbils may be produced on each pole and thereafter the plant dies. Final cutting is carried out when 75 per cent of the plants have poled. The yield of fibre per acre over a cycle varies from 3 to 5 tons.

The leaves are delivered to the factory within 24-36 hours of cutting. The fleshy material is removed by decorticators. The percentage of fibre to leaf varies from 2 per cent to 4.5 per cent according to the age of the plant. A decorticator can deal with 100 tons of leaf per day yielding 3-3.25 tons of fibre. Power requirement is about 100 h.p. Water required for washing the fibre and carrying away the waste is 200-300 gallons per minute during a ten-hour shift. The fibre is sun- or mechanically-dried to a moisture content of 10-14 per cent, then brushed, graded for length, colour and cleanliness and baled. Four to eight bales per ton with a density of 70 ft. per ton or less.

Major Uses

Baling and binder twine, ropes, bags, hessian cloth, sisal carpets, reinforcing "Kraft" papers, upholstery padding, etc.

SUGAR CANE

By S. S. Gill, Department of Agriculture, Kenya

Saccharum officinarum Kiswahili—Miwa

Climate and Soils

Sugar cane thrives best in a tropical climate free from frost and severe cold, its growth being arrested by cold conditions. There should be a period of continuous growth for at least ten months of the year. Sugar cane is grown on light-coloured brown or reddish loams of at least 3 ft. in depth, but the highest yields are obtained on rich dark clay loams, provided attention is paid to drainage.

Rainfall and Irrigation

Sugar cane is grown under a wide range of rainfall conditions varying from about 25 in. up to 100 in., but an even distribution of rainfall is essential and probably about 40 in.

coupled with timely irrigation will give the highest yields. In regions of very heavy rainfall, drainage is essential to prevent waterlogging.

Preparation of Soil

Thorough deep cultivation of the soil is essential to increase soil aeration and water-holding capacity. It is most important that all couch grass should be removed and the young cane should be cultivated frequently to reduce weed growth until the crop is able to smother the weeds itself.

Planting of Sugar Cane

Sugar cane belongs to the order Gramineae, and has typical grass-like characteristics in that its roots are fibrous and of a spreading nature. Many stems are produced from one stool and regrowth is possible after cutting.

Sugar cane is propagated vegetatively by small pieces of stem, known as "setts" of about one foot in length. Only healthy young growth, preferably from a plant crop, should be used, and it is essential to see that all eye-buds are present in a sound, healthy condition as they may become damaged in the course of trashing the cane.

Planting methods vary according to soil conditions. Generally, the setts are planted in furrows, opened by a mould-board plough, between 4 ft. and 6 ft. apart. The setts are then placed flat, touching each other in the furrows, and are covered with soil. Experiments indicate that there is no significant difference in yield between cane planted over this range of spacing. When planted under irrigated conditions the setts are covered with soil to a depth of 3-4 in., but in dry weather they are placed deeper.

To plant an acre of cane, about one to two tons of planting material are required, according to the thickness of the cane used.

Active growth takes place from the 11th day of planting if the temperature is high, and all setts should have sprouted within one month. Thereafter, all gaps in the rows should be replanted.

Weed Control

It is essential to control weed growth in the early stages until the crop has grown up sufficiently to cover the rows when the shading effect will check the growth of weeds. Hand cultivation, mechanical inter-row cultivation and, increasingly, herbicides are used to suppress weed growth.

Tillering

Initial tillering is promoted by light and heat, and in consequence the cuttings should be covered as lightly as possible with soil. Once a sufficient number of tillers have been formed, further tillering should be suppressed by earthing up.

Maturation

As the cane reaches maturity, growth ceases and the distribution of sucrose becomes more even throughout the stem. Maturation is initiated by a dry period and a reduction in the available nitrate in the soil. Under irrigation it is possible to hasten maturation by withholding water.

Harvesting

The cane should be harvested when it is fully ripe. This will depend upon the rainfall, the variety, and whether it is a plant or a ratoon crop. At harvest the cane is cut as close to the ground as possible, as the lowest portion of the stem has the highest sucrose content, the leaves are stripped off, and the tops removed. Topping should be done just above the highest node.

Ratoons

After cutting, the stools are allowed to sprout again, or "ratoon". It is usual to take a plant crop and two ratoon crops. Occasionally even a third ratoon is harvested, but generally the reduction in yield does not make the growing of this crop economic. After harvest the trash is moved into alternate inter-rows and allowed to decompose, thereby retaining the organic matter and structure of the soil. The ratoon crop is regarded as the "money" crop as the cost of field operations have already been paid for by the plant crop. Depending on local conditions, there is a tendency for a decline of from 10 per cent to 20 per cent in yield with each successive ratoon. However, with good management and adequate manuring, this effect can be minimized.

Manuring

This will depend upon the nutrient status of the soil, other environmental conditions,

such as rainfall, whether the crop is a plant or ratoon crop, and to what degree cane by-products are returned to the field.

In Nyanza Province, plant cane has shown little response to nitrogen, phosphate or potash, though economic returns have been obtained from dressings of 2½ to 3 cwts. per acre applied to the first ratoon crop. Elsewhere in Kenya good responses to both nitrogen and phosphate have been obtained with both plant and ratoon crops. Dressings of 1 cwt. of double super-phosphate and 4 cwt. of sulphate of ammonia per acre proved very profitable and the indications were that the rate of nitrogen application could have been increased still further with advantage.

Yield

A well managed field of cane should yield 40-45 tons of cane per year from the plant crop, 30-35 tons in the first ratoon, and 25-30 tons in the second ratoon, after which the plant should be replanted. These figures apply to non-irrigated cane, and under irrigation an increase in yields of approximately 50 per cent can be expected. Ten tons of sugar cane will yield about one ton of sugar or jaggery.

Varieties

There are a great many varieties of sugar cane in commercial production at present, and each year these are being increased by seedling canes, the product of various sugar cane plant breeding institutes throughout the world. They can be classified broadly into two groups:—

(1) The "Noble" canes which are usually high in sucrose content but require high rainfall conditions and fertile soils.

(2) The group of slender canes which have a strong root system, great ratooning power, and adapt themselves easily to poor lands. They mature late and have high fibre content. Most of the varieties successful in the Colony are found in this group.

The standard estate varieties are Co.421 and Co.281 to which Co.331 has now been added. In a recent trial of the best five varieties selected from previous trials (Co.331, Co.213, Co.408, Co.421 and Co.419) Co.331 outyielded all other varieties in each crop, and although it has a lower sucrose content than the others, its total yield of sucrose per acre was superior.

Diseases of Sugar Cane

The most important diseases affecting sugar cane in this Colony are:—

Ratoon stunting disease.—This is a virus disease transmitted by juice from infected stems into the stems of healthy canes by the panga when cutting.

A characteristic of the disease is to produce red streaks within the stem, particularly within the region of the nodes. It is not usually noticed in the plant cane, and for this reason great care must be used in selecting the source of planting material. In each successive ratoon, the yield drops to a greater degree than the normal fall-off in yield with the increase in age of the crop. Hot water treatment of the planting material will control the disease, but this can only be done at a central station as a thermostatic bath has to be used to control the temperature of the water accurately.

Mosaic.—This disease is becoming serious in a large number of varieties. The outward characteristics of the disease is a mottling of the leaves in the form of white blotches and streaks. There is a general reduction in the vigour of the cane, leading to a reduced yield, although the sucrose content of the juice is not affected. The only control measures are the planting of cane setts from Mosaic-free stools and the removal of the stools as soon as Mosaic appears.

Major Uses of Sugar Cane

Sugar.—The juice is extracted from the cane by passing it through a series of three roller mills. It is then limed to raise its pH and treated with sulphur dioxide until slightly acid. It is then heated and filtered, and the clear juice boiled in vacuum pans to form a syrup. This is then centrifuged to separate the sugar from the molasses.

Jaggery.—The cane juice is extracted by passing through a single three-roll mill, and is then boiled in open pans and the impurities skimmed from the surface. The clarified juice is boiled to 110° C., and on cooling sets into a solid mass called "jaggery".

By-products of Sugar Cane

Bagasse.—The fibrous part of the stem left after the juice has been extracted from the cane is called Bagasse, and is used for the production of paper, artificial silk, fibre

boards, and cattle feed. It can also be used for firing the furnaces during the extraction of the juice.

Molasses.—This is the dark syrup product left after removal of the sugar by the centrifugals. It is used for making rum, industrial alcohol, dry ice, yeast, cattle feeds, and can also be used as a manure.

Filter Press Mud.—This is used entirely for manurial purposes and contains principally lime and phosphoric acid.

Sugar Cane Tops.—The leaves and tops of sugar cane form a valuable green fodder for cattle, and as most cane is harvested in the dry season it is available at a time when grass is liable to be short.

TEA

By G. Gamble, Department of Agriculture, Kenya

Camellia Thea Kiswahili—Chai

Climate and Soils

Ideally, a well-distributed rainfall of 50 to 80 inches falling on an average of 200 days in the year. Prefers well-drained deep soils with a pH value of 4.5 to 6. In Kenya the altitude range varies from 5,000 feet to 8,000 feet above sea-level.

Tea Seed

Use only tea seed from an approved seed garden. Unsuitable seed may result in low yields and poor quality tea. Sound tea seed should contain 225 to 250 seeds per lb. Plant seed as soon as possible after putting seed in water and removing "floaters", examining sound seed for borer or caterpillar damage and cutting open 100 seeds per 1,000 lb. to check internal colour, which should be milky white. Record results in nursery book.

(*N.B.*—A week's delay in planting may cause 10 per cent loss in germination.)

Germination Bed

Prepare bed of any convenient length, up to 4 feet wide, with a surrounding frame of timber off-cuts 4 to 6 inches wide. Fill with sterilized sand to depth of 3 inches. Bed should be in warmest part of nursery and be provided with both overhead and side shade. Place seeds separately in bed, lightly cover with sand, leaving top of seed exposed. Do not apply grass mulch. Lightly water to maintain moisture without waterlogging. Regulate overhead shade as necessary. Examine seeds daily after two weeks. Remove all seeds with roots $\frac{1}{8}''$ to $\frac{1}{4}''$ and plant, root downwards, in nursery. Record germination counts in nursery book. Good seed should reach 85 per cent germination.

Nursery Bed

Dig over ground to depth of 18 inches, four to six weeks before planting. Construct raised beds across the slope, 4 feet wide, with paths $2\frac{1}{2}$ feet between beds. Thoroughly weed before planting seed but leave unshaded, as warm soil assists even growth.

When planting germinated seed, mark out holes with planting boards 4 feet wide, fitted with 2-inch spikes spaced $6'' \times 6''$ triangularly. When transporting germinated seed avoid damage to roots and exposure to sun. Plant seeds 2 inches deep with root downwards, cover lightly with soil. Apply grass mulch and water. Protect whole nursery with moderate overhead shade and dense side shade to maintain moisture and even temperature. Cold, draughty conditions are very detrimental to tea seedlings.

Keep beds clean-weeded by hand, but avoid disturbing roots of very young tea seedlings. Maintain an even short mulch and even moisture conditions by regular watering. Important to avoid waterlogging. Change mulch if necessary. Maintain adequate overhead and side shade. During second short rains after planting, gradually reduce overhead shade to harden off plants prior to planting out as two-year old "stumps". Do not reduce shade for one-year old "stumps", but ensure the provision of dense shade immediately planting is completed. Exposure of "stumps" to even one hour's direct sunlight will cause heavy mortality.

Land Preparation

Avoid sites of old cattle yards, charcoal kilns, burned tree trunks, recently cleared wattle land, badly-drained land and low-lying areas subject to frost. In the area selected, ring-bark growing trees and allow to die before felling, in order to prevent *Armillaria* attack. Remove all roots and stumps and give at least three deep cultivations and remove all couch and Kikuyu grass. Where trees have grown previously take at least one crop of maize or potatoes. Adequate soil conservation measures must be taken without causing waterlogging; construct narrow-base terraces on gentler slopes and bench terraces on steeper slopes to suit a spacing of 5 feet by 2½ feet with a single row of tea per bench.

Planting in the Field

Stump-planting is recommended owing to ease of transport. Prepare planting holes at least two months in advance, spaced at 5 feet by 2½ feet on the contour, equivalent to 3,485 plants per acre. When lifting from nursery cut-back plants to 3 inches above ground, avoid demaging tap root as far as possible, discard stumps with twisted or badly damaged tap roots, transport sound stumps to field, and plant without delay. Planting gangs should work in pairs—one holding stump at correct height (nursery level) and spreading roots whilst second fills in planting hole and firmly presses soil around the roots. Protect stump with low shade *immediately*, i.e. plant and shade simultaneously. Apply a grass mulch as soon as possible, and interplant alternate rows with *Tephrosia* or *Crotolaria*. Replant losses as soon as possible. To maintain an adequate grass mulch in the tea, it may be necessary to plant an equivalent area of grass.

Shade

Important to establish permanent shade and shelter belts as early as possible after planting. *Albizia stipulata* at 40 feet by 35 feet is recommended for the Central Province.

Pruning

Normally carried out during the coldest months of the year, i.e. July and August, but the advice of the Tea Research Institute should be sought in newly-planted areas. Correct early pruning is essential to produce a good table and ensure maximum yields.

With Young Tea.—After one year with a single stem cut back to 6 inches or just above the lowest branch. The side branch if under 11 inches is tipped, not cut. With multiple stems cut across at 11 inches from ground. After second year prune to 5 inches higher than first year's pruning, i.e. 11 inches and 16 inches for single and multiple stemmed plants respectively. *Lateral growth must be preserved* even if slightly above pruning level.

After three years in the field bushes pruned to 11 inches previously should be pruned to 16 inches and those pruned to 16 inches should now be pruned to 20 inches. Subsequent growth should be tipped to 30 inches and be plucked at regular intervals. After four years in the field the tea should be mature and all bushes should be pruned to 21 inches; then tip to 8 inches above pruning mark and pluck normally.

With Mature Tea.—Prune on two-year or three-year cycle depending on locality. Three-year cycle is probably safest in East Africa except in areas where there is a definite cold period of dormancy. Prune the bush across one inch above the previous pruning cut every second or third year. Then tip at 8 inches above the pruning cut or 30 inches above ground level which ever is the greater and this becomes the plucking table. Thoroughly clean out the bushes every two or three years taking great care to maintain the spread so as to increase the plucking surface and maintain as complete a ground cover as possible to reduce erosion and weeding. After 10 to 12 years, when bushes are too tall to pluck, prune back to 20 inches and repeat the above cycle.

Plucking

Young leaves produce the best quality tea, for which the standard of two leaves and a bud is essential. With African smallholdings a 14-day plucking round is advocated, each plot being divided into two halves which are plucked on alternate weeks. Too short a round adversely affects the tea bush whilst with too long a round the bush loses its shape and there is a considerable loss of leaf. Side-plucking checks lateral growth, thus reducing the frame and the subsequent yield and is particularly damaging to young tea bushes. Yields of green leaf should be from 4,500 to 5,500 lb. per acre, equivalent to 900 to 1,100 lb. of made tea per acre.

TOBACCO

By the East African Tobacco Company Limited, Kenya

Nicotiana Tabacum Kiswahili—Tumbaku

Climate and Soils

It is essential to combine production of acceptable commercial varieties with suitable ecological conditions of altitude, soil types, rainfall distribution and mean temperatures in order to produce tobacco leaf suitable for the manufacture of cigarettes and smoking tobaccos.

Altitude.—Should not be grown much above 4,200 feet owing to high incidence of White Mould due to colder conditions which delay ripening in the field.

Rainfall.—Minimum of 10 inches during the three months following transplanting into the field.

Temperature.—Does well with maximum of 80-85° F. and mean temperature of about 72°. Ideally the crop prefers a range of rising temperatures during the season.

Soils.—For seedbeds choose fertile alluvial or sandy loams with good humus content. In the field, flue-cured tobacco requires sandy granitic of volcanic pink to grey loams of medium fertility and good drainage. Red soils are generally unsuitable. Fire-cured and air-cured crops need heavier and more fertile soils to produce the longer, thicker leaves required for these types. Excessive rainfall, hail, high winds and lack of sunshine during the ripening period are detrimental to leaf quality.

Cultivation

It is essential to establish seedlings in nurseries before transplanting into the field. For every acre in the field allow ⅛th ounce of clean sound seed sown in 30 square yards of seed bed. Seed should be mixed with fine wood ash to assist even sowing. Nursery beds are often sterilized by burning in order to reduce damage from nematodes, insect pests and fungus diseases such as Damping off and Frog eye. Seedlings are ready to plant out in 6-8 weeks when they should be 8 inches high. Seedbeds must be kept damp always and require up to 75 gallons of water per 30 square yards daily, until the last two weeks in the nursery when the seedlings are hardened off by progressively reducing shade and water.

In the field land preparation consists of ploughing, harrowing, and preferably contour ridging prior to planting. Planting distances are:—

Flue-cured.—44″ × 22″ (6,340 plants per acre).

Fire-cured or Air-cured.—36″ × 36″ (4,840 plants per acre).

Clean weeding is essential and bottom leaves must be removed 3-4 weeks after transplanting. About 2-3 weeks later all suckers should be removed and the plants topped down to 16-18 leaves for Flue-cured and 10-12 leaves for Fire- or Air-cured. The crop takes 10-11 weeks to reach maturity in the field.

Harvesting

Tobacco ripens from the bottom upwards and is indicated by the leaves turning greenish yellow. Harvesting is usually done weekly when 1-3 leaves may be taken from each plant. Harvested leaves must be hung in the curing barn the same day. A crop takes 9-10 weeks to harvest.

Curing and Grading

Flue-cured

The harvested leaf is cured in a barn heated by a wood fuel furnace and radiation flues. A barn 16′ × 20′ and 20′ high can deal with 10-12 acres of tobacco. The ripe leaf is strung on sticks and arranged in tiers in the barn and is then cured by a varying combination of heat and humidity, first to colour the leaf and then to dry it. Temperatures range from 90° to 170° F. and the process takes approximately 140-150 hours. A single curing producing about 1,000 lb. of cured leaf requires approximately 2 tons of wood fuel. Cured leaf is then graded, according to market requirements, into a number of set commercial grades in which colour, length and texture of leaf and blemishes are the dominant factors. Before packing, tobacco leaf must be conditioned to a moisture content of about 15 per cent. Cured graded leaf is packed in hessian covered bales weighing 200 lb. net and measuring 2′ × 3′ × 1½′.

At all curing centres and tobacco handling establishments, absolute cleanliness is vital to

prevent infestation by Tobacco weevil (*Lasioderma serricorne*) and Tobacco moth (*Ephestia clutella*). All tobacco scrap and rubbish must be cleared out regularly if infestation is to be prevented. No buyer will purchase tobacco leaf containing either of these pests.

Fire-cured

African growers usually build a barn having a grass roof and mud and wattle walls, with pits in the earth floor for open fires. The walls are about 7 feet high. The barn is fitted with racks to take the leaf strung on sticks, 4 feet apart and at 2 feet vertical intervals, the lowest tier being 5 feet above the ground. A barn 12′ × 25′ × 7′ high contains approximately 150 running feet of racks and should suffice for about ⅓ acre of tobacco. Ripe leaf from the field is hung in the barn and left to change colour to yellow without any form of heat whilst maintaining a high degree of humidity within the barn. This stage may take up to a week depending on weather conditions. The next stage calls for small smouldering open fires until the leaf tips and edges begin to curl and turn brown. The fires are then extinguished and the barn cooled down to allow the brown colour to spread. This process is repeated until the whole leaf is a uniform brown colour. Thereafter smoke is not important but fires are maintained to give additional heat to dry out the midribs of the leaves. The total curing process may take 3 to 4 weeks. Hard, slow-burning wood of small diameter is required. The requirements of wood are negligible compared with those of flue-curing. It is important to avoid using wood possessing undesirable aromas which might taint the cured leaf. After curing, the leaf should be laid down in bulks and compressed under weights for a period in the right "condition" (moisture content) before grading. Graded Fire-cured tobacco is usually purchased unbaled, leaves of the same grade being tied in bunches of a diameter of about 1½ inches. East African Fire-cured leaf is generally graded into two to four grades depending on length of leaf, uniformity of colour and degree of leaf blemish and damage.

Air-cured

The curing barn used is similar to that for fire-curing, but the rack space should be increased as air-curing takes longer. The leaf is hung in the barn and the humidity inside is kept high until the leaf turns yellow, after which humidity is reduced to a minimum. The leaf turns brown of its own accord and then dries. Sometimes open fires may be necessary in which case they should be charcoal fires which give no aroma. Grading and packing are carried out as for Fire-cured tobacco and in both cases the same precautions are necessary against tobacco weevil and tobacco moth.

YIELD

700-800 lb. of cured leaf per acre is a fair average yield.

MAJOR USES

Smoking tobacco for cigarettes, pipes and cigars, snuff tobaccos and nicotine extracts for insecticides.

REVIEW

A NOTEBOOK OF TROPICAL AGRICULTURE, by R. Cecil Wood, Sixth Edition, published by the Imperial College of Tropical Agriculture, Trinidad, British West Indies, 1957, pp. 256, price 12*s*. 6*d*.

The sixth edition of this useful pocket reference book has been revised and enlarged by the staff of the Imperial College of Tropical Agriculture under the editorship of Professor A. B. Killick. New sections have been added on soil and water conservation, grasses, insecticides, fungicides and herbicides, while the sections on weights and measures, labour, machinery, manures and fertilizers, feeds and feeding, animal husbandry, and statistics have been expanded and brought up to date. The previous five editions have proved their value during the past 24 years, but this revised edition can be recommended even more strongly to agricultural officers, farmers, and others who require quick references to facts and figures on tropical agriculture.

D.W.D.

OBSERVATIONS ON THE GROWTH OF NON-IRRIGATED LUCERNE

By R. Strange, Grassland Research Station, Department of Agriculture, Kenya

(*Received for publication on 5th June, 1958*)

Pure stands of dryland lucerne have for long been recognized as an important source of high quality feed for livestock in the Argentine, Australia, U.S.A. and elsewhere. By comparison, little use is being made of non-irrigated lucerne in Kenya, the bulk of our production at the moment coming from areas such as the shore of Lake Naivasha, which have fertile soil and adequate sub-surface water, or from stands which are grown elsewhere under irrigation. Undoubtedly, far more use could be made of lucerne in this country, both in pasture mixtures and in pure stands, and a good deal of attention is therefore now being given by the Agricultural Department to this aspect, especially at the Grassland Research Stations at Kitale and Molo.

In April, 1954, an experiment was established with the object of obtaining some preliminary information on the growth and chemical composition of non-irrigated lucerne in pure stand, with special reference to the optimum row spacing for the local conditions. The altitude at Kitale is about 6,200 ft., the mean annual rainfall about 45 inches, and soil is a medium sandy loam derived from the basement complex, having an average pH of between 5.5 and 6.0.

The plots were laid down in three randomized blocks, in which row spacings of 1 ft., 2 ft., 3 ft. and 4 ft. were compared. The plants were thinned to 6 in. apart within each row.

At a relatively late stage in the experiment it was decided to split the plots for the introduction of a gypsum treatment, as pot tests, carried out by Dr. E. M. Chenery at Kawanda Research Institute, Uganda, had revealed evidence of a possible sulphur shortage in the soil. The full manurial programme was therefore as follows:—

(i) Basal dressings of agricultural lime at 2½ tons an acre, triple superphosphate at 1½ cwt., and muriate of potash at 1½ cwt. an acre were applied at the start of the experiment.

(ii) The applications of phosphate and potash were repeated annually at the beginning of each season.

(iii) Gypsum was applied to split plots at 1½ cwt. an acre in July, 1956, and again at the same rate in March, 1957.

It is not suggested that farmers should apply fertilizers at these rates, as from an economic viewpoint the dressings were probably unnecessarily high, and should be regarded as experimental. Until more information is forthcoming about the manurial requirements of lucerne on these soils it is suggested that only dressings of triple superphosphate (or its equivalent in other phosphatic fertilizers) and gypsum should be applied at the rate of 1 cwt. each per acre annually, together with applications of compost or F.Y.M. if available.

Rainfall during the experiment is shown in Table I.

TABLE I—RAINFALL RECORD
(*Inches*)

	1954	1955	1956	1957
January ..	—	1·76	2·12	0·94
February ..	—	1·23	3·10	0·15
March ..	—	0·45	2·56	3·19
April ..	4·80	3·49	5·75	6·75
May ..	5·52	4·44	6·85	9·24
June ..	4·59	3·19	2·70	4·66
July ..	5·31	4·58	4·72	4·18
August ..	5·71	6·17	7·50	5·96
September ..	5·28	6·28	4·46	—
October ..	1·69	2·83	4·73	—
November ..	1·45	1·42	0·56	—
December ..	2·32	4·87	0·75	—
Totals ..	36·67	40·71	45·80	35·07

An examination of all the figures failed to reveal a clear relationship between rainfall and dry matter content of the fresh herbage during the growing season, except at the end of the rains when the dry matter percentage rose.

Neither the differences in row spacing nor the application of gypsum had any significant effect on the dry matter content of the herbage, which averaged about 28 per cent.

During the season of establishment fresh yields only were recorded, and the result is given in Table II.

TABLE II—MEAN YIELD OF FRESH MATERIAL DURING THE ESTABLISHMENT SEASON 1954 PRIOR TO THE APPLICATION OF GYPSUM

(*Tons per acre*)

Spacings	1 ft.	2 ft.	3 ft.	4 ft.	S.E. of difference between means
Green yield	8·59	7·47	7·80	6·62	0·51

The yield of the 1 ft. spacing was significantly higher than that of the 4 ft. spacing.

In view of the uniformity in dry matter content at the four spacings it can safely be assumed that the differences, on a dry matter basis, would have been of the same order.

From the 1955 season onwards all yields were expressed in terms of dry matter, and have given the results shown in Table III.

TABLE III—MEAN YIELDS OF DRY MATTER DURING THE 1955, 1956 AND 1957 SEASONS NO GYPSUM APPLIED

(*Cwt. per acre*)

Season	Row Spacing				S.E. of difference between means
	1 ft.	2 ft.	3 ft.	4 ft.	
1955 ..	52·6	56·2	66·0	65·8	4·4
1956 ..	35·0	38·6	38·2	38·6	9·0
1957* ..	15·9	20·0	17·3	17·0	7·3
Total ..	103·5	114·8	121·5	121·4	—

*NOTE.—The 1957 yield does not represent a full season's growth as the experiment was discontinued some months before the season ended. The yield is therefore substantially lower than those of the previous three seasons.

There were no significant differences between the yields in any one season, although after the year of establishment the general trend was in favour of the wider rows, as illustrated by the totals in Table III.

Gypsum was applied to split plots for the first time in July, 1956. The yield from that date until the termination of the experiment a year later is given in Table IV. These figures represent the yield from the middle of the third season to the middle of the fourth, and, for practical purposes, may be regarded as a year's total.

TABLE IV—THE MEAN DRY MATTER YIELD OF LUCERNE SHOWING THE EFFECT OF GYPSUM APPLICATIONS

(*Cwt. per acre*)

	Row Spacings				Overall mean
	1 ft.	2 ft.	3 ft.	4 ft.	
Control ..	27·81	34·64	32·66	32·82	31·98
Gypsum ..	46·38	45·46	42·79	38·93	43·39
Mean percentage increase due to gypsum	% 66·8	% 31·2	% 31·0	% 18·6	

A statistical analysis of these figures shows that gypsum caused a highly significant increase ($P=0.001$) in the dry matter yield of the lucerne, the effect being very pronounced in the close row spacings and becoming progressively less with the wider spacings.

The response of the lucerne to gypsum, which was very marked after the initial dressing, tended to decrease as the year progressed. This is illustrated by the yields of the individual harvests which are shown in Table V.

TABLE V—THE MEAN RESPONSE OF LUCERNE TO GYPSUM APPLICATIONS DURING A TWELVE-MONTH PERIOD

(*Cwt. of dry matter per acre*)

Date of Gypsum application	Date of cut	Yield		Percentage increase due to gypsum
		Control	Gypsum	
1½ cwt./acre on 30th July, 1956	Sept., 1956	4·6	6·8	48%
	Nov., 1956	5·6	8·2	46%
	Dec., 1956	3·6	5·2	44%
	Feb., 1957	0·6	0·8	33%
1½ cwt./acre on 13th March, 1957 ..	May, 1957	8·7	11·0	26%
	June, 1957	5·6	7·2	29%
	Aug., 1957	3·3	4·1	24%

The reason for the diminishing response is in doubt, but it is thought that it may possibly be due to some other soil nutrient shortages, which are as yet unidentified, having come into effect.

It should be noted here that the effect of gypsum on lucerne in pure stand appears to be rather variable, as in some other unpublished trials at the Grassland Research Station, Kitale, the responses have been much less marked or even insignificant.

The lucerne seed had been inoculated immediately before sowing but failed to make satisfactory nodulation. Examination of the roots showed the following results:—

July 1954: No nodules present $3\frac{1}{2}$ months after sowing.

July 1955: Numerous small nodules of a green or brownish-green colour.

July 1956: Very few whitish coloured nodules.

It is probably safe to assume that the inoculant failed and that the nodules which appeared later were from a relatively ineffective strain of rhizobia.

The plots were clean-weeded and were cut simultaneously when at the budding and early flowering stage. Weeding was found to be easier in the wide rows than in the narrow ones. Some damage was caused by a root-eating caterpillar, *Marshalliana bivittata* (*Metarbelidae*). Most of the harm was done during dry periods, and the result of this was a progressive thinning out of the stands, especially at the closer spacings.

It was found that leaf diseases (probably *Pseudopeziza medicaginis* and *Uromyces striatus*) became progressively less severe as the row spacing increased, with a corresponding increase in the general vigour of the plants.

Scoring for health and freedom from disease prior to each cut resulted in the overall means throughout the experiment given in Table VI.

TABLE VI—MEAN SCORES FOR HEALTH AND FREEDOM FROM DISEASE

Spacing:	1 ft.	2 ft.	3 ft.	4 ft.
Scores:	1·7	2·0	2·6	2·7

The basis of scoring was:—

5—Very healthy green appearance. No leaf disease.

4—Generally healthy appearance but leaf disease starting to appear.

3—Some yellowing. Mild leaf spot occurring throughout but no shedding of leaves.

2—Generally diseased appearance. Quite advanced leaf spot with some shedding of leaves.

1—Very diseased, severe leaf spot and shedding of leaves.

The records of average height of the plots prior to each cut show that the wider spacings resulted in taller growth. Also flowering was generally more advanced in the wide spacings.

The contents of crude protein, calcium and phosphorus (on a dry matter basis) averaged 20.8 per cent, 1.4 per cent and 0.26 per cent. Neither the differences in row spacing, nor the gypsum applications, have had a significant effect on these, although there appears to have been a slight increase in calcium where gypsum was applied.

The frequency with which dryland lucerne can be cut or grazed under these conditions is of interest. There was a total of 28 cuts over a period of 41 months, or a cut every 5 to 6 weeks on the average throughout the life of the stand.

Summary of Results

During the establishment year dryland lucerne in 1 ft. rows yielded significantly more than lucerne in 4 ft. rows. Subsequently this was reversed and there was a tendency for the yields to be higher at 3 ft. and 4 ft. spacings. The health and vigour of the stand was considerably better in wide rows than in narrow ones and furthermore, the wider spacings facilitated weeding and cultivation. In view of these considerations, row intervals of 3 ft. to 4 ft. are advocated for non-irrigated lucerne under the conditions described.

Applications of gypsum resulted in highly significant yield increases, but these became progressively less at each cut during a twelve-month period. The beneficial effect of the gypsum was more pronounced in close rows than in wide rows. It is noted that the responses to gypsum by pure stands of lucerne appear to be rather variable on the Kitale soil.

Neither the different spacings nor the application of gypsum had any significant influence on the percentage of dry matter in the herbage or on the crude protein, calcium, or phosphorus content of the dry matter.

The yields which were obtained in this experiment could no doubt be improved upon, as neither the inoculation nor the nutrition of the lucerne was entirely satisfactory during the complete life of the stand.

A NOTE ON THE CONTROL OF BEAN PESTS IN UGANDA

By J. C. Davies, Department of Agriculture, Uganda

(*Received for publication on 27th June, 1958*)

Stored legumes in the tropics are very susceptible to attack by members of the insect family *Bruchidae*. Uganda is no exception, and a recent survey of storage on African farms and Indian stores in Northern Uganda revealed that infestation was frequently very high. The damage these beetles cause is such that the institution of control measures would be well worth while.

Life History of the Pests

In Uganda there are three main pests of stored legumes, (1) *Acanthoscelides obtectus* (Say), the Bean Beetle; (2) *Callosobruchus chinensis* L., the Cowpea Beetle; and (3) *Callosobruchus maculatus*. F., the Southern Cowpea Beetle. All three of these fly actively and can move from stores to the field and vice versa. Infestation can, therefore, start in the field, but the really big build-up occurs when the beans are stored.

Acanthoscelides obtectus (Say). The Bean Beetle

The female beetle lays her eggs on the green pod or through cracks in the drying pod. The eggs may also be laid loosely among the beans or pods in store. In Uganda beans of the kidney variety are especially favoured by the beetle.

The adult beetles do not feed, and live for about two weeks in tropical conditions. The female lays 200 eggs or so, mainly in her first week of life. These hatch in about five days into larvae which, after wandering about over the beans for a short time, bore into them, leaving behind a hole which is scarcely detectable. In a growing pod this hole may heal over completely.

The grub, which is white, soft and legless, continues to feed inside the bean and becomes full-grown in two to three weeks. At this stage it can be located lying under the skin of the bean in a small cell which is detectable as a darkish circular patch of skin on the bean surface. In this cell the larva changes into a non-feeding form or pupa which after five or six days becomes a mature adult in warm conditions. The adult emerges by cutting out the circular flap of skin mentioned above leaving the characteristic round hole typical of Bruchid damage. If the original infestation occurred in the field the cycle then starts all over again when the beans come into store, but clean beans coming into dirty stores can be infested. In stores the females lay their eggs loose among the beans or on the receptacle containing them. Six to 12 generations develop in a year.

Callosobruchus Spp. The Cowpea Beetles

These have a similar life-cycle to the bean beetle, but in Uganda are commonly found on the smaller legumes, e.g. cowpeas, green gram, pigeon peas, etc. They are smaller in size than the bean beetle and also differ from the latter in that the females stick their eggs firmly to the pod or pea. The eggs can usually be clearly seen as white specks on stored legumes. Each female lays about 200 eggs. The larvae on hatching bore straight into the bean without wandering over the bean surface. Once again the emergence of the adults leaves the characteristic round hole. The adult does not feed and lives about one week in Uganda, but in cool conditions can survive for a longer period. The life-cycle, egg to mature adult, occupies about three weeks.

Experiments in the Control of Acanthoscelides Obtectus (Say)

Tests have been carried out at Kawanda using the dosage recommended in the United Kingdom, i.e. 8 oz. of 0.04 per cent gamma B.H.C. dust per 200 lb. of beans.

Method

The freshly harvested beans were first sun-dried on barbecues and then threshed. Each batch was divided into two lots, one lot treated with insecticide, the other lot serving as a control. Mixing of the insecticide was done by hand since the quantities involved were small (600-lb. lots). The beans were then placed in iron drums (old cleaned oil-drums) with well-fitting lids. Monthly counts were carried out.

Sampling

Five-hundred-bean samples were used to assess the progress of the infestation. These were obtained from larger samples taken from

the top and bottom of the bins. The bottom samples were obtained using a 1¼-in. grain-sampling spear. It was found that five probes with the spear strategically placed gave us a sample of requisite size and uniformity. After counting, the 500-bean sample was weighed.

A note was taken of mouldiness, shrivelling, split beans and otherwise damaged beans, but the chief aim was to obtain an estimate of insect damage, both by Bruchids and other insects. Since Bruchid damage is so characteristic it was possible to make the distinction between Bruchid damage and other field pest damage. It was quickly apparent that the damage due to the latter was negligible. Though many of the discoloured and shrivelled beans may have resulted from attacks by Hemiptera, this needs further study. The beans were slightly Bruchid-infested on arrival from the field.

The number and weight of beans damaged was recorded for each sample and the whole samples were also sieved for Bruchids.

Trial 1

From Table I it is immediately apparent that the percentage bored by number increases steadily to a high figure in the untreated beans. The treated beans maintain a low level of infestation throughout the period of the experiment though there is a slight rise in the number bored by Bruchids due to the fact that these beans had been held for a while before the trial was laid down and some emergence did take place.

A fact which emerges is that the tops of bins are more heavily infested than the bottoms in the untreated series. That no such difference was detected in the treated lots was probably due to the very low percentage damage. It is suggested that the difference in the untreated between top and bottom is due to beetles coming to the surface to mate and laying most of their eggs in the upper layers rather than penetrating the mass to any extent to lay their eggs. It has been suggested that Bruchid-damaged beans stimulate the females to oviposit and once there is a surface infestation this process is accentuated. A feature not entirely in keeping with this was that more Bruchids were sieved out of the bottom samples than the top (*see* Table II). But this was probably due to the natural tendency for small objects to move downwards through a mass. A large percentage of these Bruchids were dead, but in view of the short life of adult Bruchids this is not surprising.

TABLE I.—NOVEMBER, 1956

	UNTREATED				TREATED			
	No. damaged by Bruchids	No. damaged by other field pest	Per cent by weight Insect damaged	Per cent by No. damaged Bruchids	No. damaged by Bruchids	No. damaged by other field pest	Per cent by weight Insect damaged	Per cent by No. damaged Bruchids
			per cent	*per cent*			*per cent*	*per cent*
SAMPLE— Initital	5	2	1·3	1	3	1	·7	·6
1ST MONTH— Top	9	1	2·4	2	3	1	·9	·8
Bottom ..	11	3	2·1		5	1	1·0	
2ND MONTH— Top	25	7	6·3	4·4	6	1	1·2	·9
Bottom	19	3	4·1		3	3	1·2	
3RD MONTH— Top	91	3	21·2	12·7	5	3	1·4	1·4
Bottom	36	4	8·3		8	4	2·3	
4TH MONTH— Top	110	6	21·9	16·2	6	—	1·2	1·4
Bottom	52	—	10·3		8	—	1·5	
5TH MONTH— Top	264	—	52·8	38·4	8	1	1·7	1·5
Bottom	120	—	24·6		7	1	1·7	

TABLE II.—NO. OF BRUCHIDS SIEVED OUT OF SAMPLE IN TRIAL I

Untreated	No. of Bruchids	Treated	No. of Bruchids
3RD MONTH			
Top ..	62	Top ..	4
Bottom ..	71	Bottom ..	10
	133		14
4TH MONTH			
Top ..	169	Top ..	18
Bottom ..	197	Bottom ..	54
	366		72
5TH MONTH			
Top ..	199	Top ..	7
Bottom ..	230	Bottom ..	30
	429		37

This trial had to be discontinued because the insect population became so large that heating occurred which in turn caused translocation of moisture. This moisture condensed at the sides and bottom of the bins, resulting in a soggy mass which became mouldy, stinking and quite unusable.

Trial 2

In this trial (*see* Table III) the infestation developed more spectacularly, reaching a very high figure by the third month. Again infestation at the top of the bin was heavier, but after the third month this was not so pronounced. After six months' storage the beans in the untreated bin were in a very poor state and were riddled with Bruchids.

TABLE III.—NOVEMBER, 1956

	Untreated				Treated			
	No. damaged by Bruchids	No. damaged by other field pest	Per cent by weight Insect damaged	Per cent by No. damaged Bruchids	No. damaged by Bruchids	No. damaged by other field pest	Per cent by weight damaged Bruchids	Per cent by No. damaged Bruchids
			per cent	*per cent*			*per cent*	*per cent*
INITIAL SAMPLE ..	0	1	—	·0	0	2	·5	·0
1ST MONTH—								
Top	0	1	·2	—	2	0	·5	—
Bottom	1	1	·4	·1	3	0	·3	·5
2ND MONTH—								
Top	56	0	11·1	15·6	3	0	·5	·4
Bottom	100	3	19·5	—	1	0	·2	—
3RD MONTH—								
Top	270	1	53·3	36·2	2	2	·6	·3
Bottom	92	0	18·4	—	1	0	·2	—
4TH MONTH—								
Top	229	1	45·5	42·4	0	0	·0	·3
Bottom	195	2	39·7	—	3	0	·7	—
5TH MONTH—								
Top	285	2	57·7	54·6	2	1	·6	·4
Bottom	261	2	52·1	—	2	3	·7	—
6TH MONTH—								
Top	397	2	79·4	69·4	2	0	·4	·3
Bottom	297	0	59·8	—	1	1	·3	—

Weight Loss

The calculation of weight loss caused by insects is difficult because many factors have to be taken into consideration. The last collected figures for the 500 bean samples in Trials 1 and 2 are given in Table IV and represent a weight loss of 4.3 per cent over six months in Trial 1, and 4.9 per cent over six months in Trial 2. (Initial sample weights in brackets.)

TABLE IV

	Untreated	Treated
TRIAL I—		
Top	164·9g (179·50g)	180·1g (179·0g)
Bottom ..	174·8g	174·8g
TRIAL II—		
Top	160·6 (179·9)	176·4 (178·0)
Bottom ..	172·2	173·7

The true weight loss is however undoubtedly greater than this since it is impossible to dissect every bean and remove all larvae and dead insects. The matter is also complicated by the fact that insects produce metabolic water which causes beans in the untreated bins to pick up moisture which compensates for the weight lost to insect feeding. Even so, a weight loss of almost 5 per cent has been demonstrated. In an effort to obtain a further figure several lots of 100 bored beans were weighed against an equal number of unbored beans. The average weight loss between bored and unbored was found to be 12.8 per cent in 12 counts. From these figures it would appear that a 50 per cent damaged sample would show a weight loss of 6.4 per cent.

The price of a bag of beans sold in a store is in the region of Sh. 60. The loss to insects is 10 lb. worth about Sh. 3. It is obvious that at this level it is worth treating the beans with 8 oz. of 0.04 per cent gamma B.H.C. which costs 60 cents. (The cost is considerably less if the B.H.C. is bought in bulk, i.e. 56-lb. bags —25 cents per 200 lb. of beans.) Allowing 40 cents as labour charge for a big buyer of beans this is a saving of Sh. 2 per bag. It is, however, useless treating the beans at this late stage, i.e. the stage immediately before the beans pass to the consumer. It would be well worth large buyers of beans paying a premium for treated beans or providing the primary buyer with B.H.C. for admixture.

It is much more difficult to demonstrate the usefulness of the measure to a peasant farmer who gets, say, Sh. 20 for his 200-lb. bag of beans. For him treatment is obviously borderline economics. However, the statement is often made that the Uganda farmer cannot store his beans because of insect attack and therefore sells off his whole crop and later in the season has to buy back at a very inflated price, either for consumption or seed. In this case treatment is obviously worth while.

A further factor is the loss of protein caused by these beetles. Diets in Africa are often deficient in protein and it is of the utmost importance to increase protein intake. Signs of dietary imbalance can be seen in the population but the intricacies of dietary balance are beyond the knowledge of the average peasant, and represent for him a fairly abstract reason for the very real expenditure of 60 cents. The peasant farmer will only realize a food loss in terms of weight or cash loss at present. Appreciation of protein content loss must await education of the masses.

No exact information is available on weight losses in pigeon peas, gram and cowpeas, but the loss is certainly as great if not greater than that demonstrated above. Time and again lots of pigeon peas were seen either in gourds or drying out in the sun with 50 to 60 per cent bored by Bruchids.

Recommendations

A considerable saving has been demonstrated where beans are dusted with 0.04 per cent gamma B.H.C. dust at 8 oz. per 200 lb. Therefore, all beans which are to be stored in Uganda for more than three months should be treated. The earlier this treatment is applied the better, since the labour involved in treating large amounts of beans is considerable. The ideal place for treatment would be either on the peasant holding or the primary buyer's post. It would be well worth large buyers of beans supplying primary buyers with the insecticide or giving a premium for treated beans.

Mixing of the insecticide is best done by making a neat pile of beans, say five bags at a time, on a smooth floor and then shaking the requisite amount of B.H.C. evenly over the whole pile. The insecticide is then well mixed with shovels. Afterwards the beans can be rebagged.

Another method which was tried was mixing with a pepper-pot shaker as the bags were filled. This was not as satisfactory as shovel mixing, and workers complained that the dust irritated eyes and throat. No such complaints were voiced about shovel mixing. Smaller amounts of beans can have the insecticide mixed by hand and can be stored satisfactorily in old oil-drums.

There is no fundamental reason why the method should not work in African mud granaries and a trial will be laid down at the first opportunity.

Summary

A brief description of the life histories of the common Bruchid pests of legumes in Uganda is given.

Results of trials admixing 8 oz. of 0.04 per cent gamma B.H.C. dust with 200 lb. of beans are given.

Weight loss and damage figures are given.

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REVIEW

FARM MACHINERY, by C. Culpin, Fifth Edition, published by Crosby Lockwood & Son Ltd., London, 1957, pp. 668, price 35*s*.

This surprisingly comprehensive book covers a wide range of farm power equipment implements and machines. There are clear expositions of the principles on which the main farm implements and power units are designed together with well-illustrated surveys of the range and capacities of machines available for each main task. Some of the really important points, such as the principles, practice and settings of tractor hitches for ploughs and other implements, and the method of working and principle of adjustments of the binder's knotting mechanism, are given in satisfying detail. Sheer limitation of space has limited discussions on subjects such as electric motors, on which ample textbooks are available, but their application to farm work is fully treated. Crop-drying equipment is treated in detail.

In these days of increasing application of insecticides, weedicides, fungicides and fertilizers, the chapter on pumps and spraying machinery is most useful. The section on irrigation is disappointing, but the five pages devoted to it probably represent a fair reflection of its present small importance in the U.K.

Attractively printed and illustrated, the 670 pages of close-packed information rank Mr. Culpin's book with the famous compendium of Mr. Primrose McConnell of the previous century. This book has effective practical application to East Africa and should be on the desk of every practical farmer, and of all Agricultural Officers who have to work in mechanized agriculture.

H.C.P.

THE AFRICAN WEED CONTROL CONFERENCE VICTORIA FALLS, JULY, 1958

By G. W. Ivens, Colonial Pesticides Research Unit, Arusha, Tanganyika

The growing interest in the use of herbicides in Africa is shown by the fact that only 18 months after the first conference on weed control was held in Kenya (*see* this *Journal*, Vol. 23, 1957, pp. 1-37), another meeting devoted to this subject took place in Southern Rhodesia. This conference was held at the Victoria Falls Hotel from 23rd-25th July, 1958, and was organized by Messrs. Fisons Pest Control Ltd. It was attended by 59 delegates, 25 from Southern Rhodesia, 17 from the Union of South Africa, eight from the United Kingdom, four from Kenya, and one each from the United States of America, Northern Rhodesia, Tanganyika, Mauritius and the Belgian Congo. Government departments, the principal agricultural chemical firms, universities and the farming community were all represented. The conference was opened by the Hon. J. M. Caldicott, Federal Minister of Agriculture, with Mr. C. E. Horton, Research Director, Fisons Ltd., as chairman.

Results of the work being undertaken in the various territories were reported under the headings: Bush and scrub control; Weed control in grain crops; Control of perennial grasses; Weeds in plantation crops; and General weed problems. In addition, a number of papers on the more fundamental aspects of herbicide action were presented. The full report of the Conference will be published early in 1959 by Messrs. Fisons Pest Control, Chesterford Park, near Saffron Walden, Essex, England.

Among the more fundamental papers, one by Woodford [29] gave a survey of the modes of action of the different types of chemical used as herbicides. He stressed the point that, where research is being done to extend the use of herbicides in Africa, a knowledge of their mode of action is essential if time is not to be wasted in testing unsuitable chemicals, formulations, methods of application, etc. Prof. G. E. Blackman [4] spoke of the differences in spray retention which take place when the physical properties of the spray solution are altered. These differences in retention can be related to the selective action of some herbicides and the changes occurring with alteration of the properties of the solution can be utilized either to increase or decrease selectivity. The technique of conducting field trials for the assessment of herbicides was discussed by Fryer [12] who also illustrated a number of types of sprayer which have been developed for experimental herbicide work.

Prof. A. S. Crafts [9] contributed a paper describing his recent work with radioactively labelled chemicals to trace the uptake and distribution of herbicides in plants. Using this technique he has shown considerable differences in the movement of different chemicals. 2,4-D applied to leaves, for example, shows rapid movement to the shoot-tips and roots of plants which are growing vigorously but, with plants growing under conditions unfavourable to growth, very limited movement occurs. Aminotriazole, on the other hand, appears to be translocated readily under a wide range of conditions. With some chemicals there is evidence that movement from leaf to roots can be followed by exudation from the roots into the surrounding medium.

Bush and Scrub Control

Under this heading four papers were presented. West [27] surveyed the problem of bush encroachment in the Rhodesias and Nyasaland and concluded that the limitation of grazing by woody growth is of widespread and increasing importance. Experiments on veld management have shown that controlled burning can be of great value in maintaining open grassland, but the point was stressed that the grazing potential would be increased if the bush could be controlled by chemicals instead of fire. The results of arboricide trials on Southern Rhodesian bush species were presented in a paper by Cleghorn and Cronin [7]. So far, chemicals have only achieved limited success against species such as *Pseudoberlinia globiflora, Brachystegia spiciformis, Acacia rehmanniana,* etc. Of the materials tested, solutions of arsenious oxide have given better results than 2,4,5-T in diesel oil, ammonium sulphamate, etc., and treatment of stumps has been more successful than basal bark application. It is considered that ground

application of chemicals is too slow and expensive for large-scale pasture improvement and that attempts should be made to find a treatment which is effective when applied from the air. Similar bush problems in East Africa were described by Ivens [16]. 2,4,5-T appears to have given better control of *P. globiflora* and *B. spiciformis* in Tanganyika than in Southern Rhodesia but this chemical has been relatively ineffective against *Tarchonanthus camphoratus* (Leleshwa) and *Euclea divinorum*, species of particular importance in Kenya grasslands.

In the final paper in this section Tas [24] gave an account of trials in the Belgian Congo on the chemical destruction of old banana plants in order to check the spread of diseases. 2,4-D was found very effective for this purpose, and its use was considerably cheaper than manual destruction.

Weed Control in Grain Crops

According to some reports, the effects of weeds on maize are most important during the early stages of growth of the crop. Papers by Tattersfield and Cronin [26] and Parker and Ashby [20] showed that post-emergence sprays of 2,4-D or MCPA are effective in controlling most of the dicotyledonous weeds over the critical period, but that grasses and *Cyperus* species are not adequately controlled. Correctly timed pre-emergence applications control some of the worst annual grasses such as *Eleusine africana* but are less effective against such dicotyledons as *Datura* spp. and *Galinsoga parviflora*. A mixture of MCPA and 2.3,6-trichlorobenzoic acid (available under the trade name CP 1815) applied as a pre-emergence spray shows promise of killing a wider range of weeds than 2,4-D or MCPA alone though work by Gregory [13] in Kenya raises doubts as to whether it is safe to use on maize. A report on another new pre-emergence herbicide, 2-chloro-4,6-bis-ethylamino-S-triazine (Simazin), was presented by Ivens [17]. Maize has a very high degree of tolerance to this chemical, it is effective against a wide range of weeds and its effects persist for a longer period than those of 2,4-D. It appears to have certain limitations with regard to the soil and weather conditions at the time of application but is sufficiently promising to warrant more detailed investigation. In South Africa, experiments on maize described by Hattingh [14] have shown that control of weeds can increase the yield as much as an application of fertilizer. The reduction in yield caused by weeds appears to be greater the higher the level of fertility and evidence is available suggesting that the competitive effects of weeds are most important during the second month after planting. Early application of 2,4-D or MCPA will not provide control for as long as this and subsequent cultivation is usually needed to obtain a maximum yield.

Control of weeds in sorghum by post-emergence application of MCPA or 2,4-D was also shown to be practicable in a report on trials in the Sudan by Pfeiffer and Burleigh [21]. With sprays applied three weeks after sowing, 1 lb./acre of either chemical slightly reduced the crop stand but yields were considerably increased. 0.5 lb./acre had no damaging effect on the crop, but did not give quite such effective control.

The control of grass weeds in cereal crops is always difficult, but a successful solution to one such problem—killing *Echinochloa holubii* in rice—was reported by Byers and Parker [6]. Their method takes advantage of the fact that shortly after emergence the leaves of the grass weed seedlings are spread out horizontally over the ground while the rice shoots are vertical. The weed seedlings are thus susceptible to the effects of a contact herbicide treatment, such as PCP at 2-3 lb./acre, while the crop seedlings retain insufficient spray to cause more than temporary injury.

Referring to wheat, Hattingh [14] stated that spraying with either MCPA or 2,4-D is now standard practice in parts of South Africa. 2,4-D ester is used on a large scale as an aerial spray and the cost of aerial application has been brought down to the order of Sh. 10 per acre. There is evidence that "hormone-resistant" weeds are increasing in the wheat-growing areas. Similar observations have been made in Kenya, but Gregory [13] has shown that many of the species resistant to these chemicals in East Africa can be controlled with CP 1815.

Control of Perennial Grasses

Various species of rhizomatous or stoloniferous grasses are serious weeds in many parts of Africa, especially in perennial crops. Work in Tanganyika described by Ivens [18] suggests that Dalapon is a very promising chemical for controlling such "couch-grass" species as *Digitaria scalarum* and *Cynodon* spp. in coffee. Although more experimental work is required

to determine its effects on coffee trees growing under different conditions this chemical is already being used by a number of coffee growers in East Africa.

Similar work in Kenya was reported by Fleming [11] who has also tested the chemical in other crops. Preliminary results suggest that tea is less affected than coffee while sisal and pineapple also appear sufficiently resistant to make control of couch-grasses possible.

Another chemical being tested for perennial grass control is amino-triazole which has an advantage over Dalapon in that it kills many dicotyledonous weeds as well as grasses. Considerable variation was reported, however, in the results so far obtained with this chemical.

Weeds in Plantation Crops

This section included reports on sugar cane, lucerne, groundnuts, cotton and tobacco.

In Mauritius Rochecouste [23] showed that sodium and potassium salts of MCPA applied at a rate of 4 lb./acre are more effective than sodium or amine salts of 2,4-D as pre-emergence sprays in sugar cane and the difference is attributed to the longer persistence of MCPA in the soil. Bjorking [3] reported that, on an irrigated sugar-estate in Tanganyika, MCPA is also used for pre-emergence application, generally at a rate of 2 lb./acre. 2,4-D amine is normally employed for post-emergence application. It is mostly applied from the air and gives satisfactory control both of dicotyledonous weeds and of *Cyperus* spp. It has been found that aerial application of sodium 2,4-D at 2 oz./acre to cane a short time before harvesting can give an increase in sugar content of 0.5-1.0 per cent.

In South African sugar plantations, according to Hattingh [14], 2,4-D or MCPA alone are not considered sufficiently effective against *Cyperus* spp. and TCA or PCP are added to the spray. Although these mixtures give better kills of *Cyperus* they do not affect the underground tubers, and the PCP mixture in particular causes temporary damage to the cane. There is, therefore, a demand for better chemicals to control this type of weed.

The problem of weed control in lucerne was discussed by Rocco [22] who has found a mixture of DNBP at 0.4 lb./acre and ammonium sulphate at 4 lb./acre a very effective treatment on established lucerne. On seedling lucerne, 2,4-DB at 0.15 lb./acre mixed with DNBP at 0.6 lb./acre is also very effective and it is thought probable that these rates can be further reduced if ammonium sulphate is also added to the mixture.

Trials on groundnuts reported by Parker [19] suggest that MCPB and 2,4-DB may be used as post-emergence sprays on some varieties but only before the plants reach a diameter of 6 in. Pre-emergence application of MCPA and 2,4-D is a recommended treatment for this crop in South Africa.

A survey of the weed flora in the Sudan Gezira cotton scheme was made by Wilson-Jones [28]. The weeds of this area are predominantly annual and are very uniform over the whole scheme. In the crop rotation adopted cotton is always preceded by a fallow and it has been shown that, by keeping the fallow land free of weeds, considerable increases in the subsequent crop can be achieved.

Sterilization of tobacco seed-beds aims at controlling not only weed seeds, but also a number of other organisms capable of affecting the growth of tobacco seedlings, such as nematodes, fungi, insects, etc. Cronin [10] discussed the chemical and other methods of soil sterilization and concluded that the fumigant, methyl bromide, was one of the most effective and least persistent chemicals available. Being a poisonous gas, however, it must be used with great care.

General Weed Problems

This section included two papers on Water hyacinth (*Eichhornia crassipes*). In Southern Rhodesia, according to Bates and Phipps [2], the weed is at present restricted to a few dams and lake shores. It shows little tendency to colonize the larger rivers, but is considered capable of becoming a serious problem on Lake Kariba and the lower Zambesi. Eradication is therefore being attempted but it is not proving easy. The weed is being treated at three-monthly intervals with 2,4-D amine at a rate of 3 lb./acre. This effectively kills most of the plants, but reinfestation occurs from seed or from plants sheltered from the spray.

The much more serious *Eichhornia* problem in the Belgian Congo was described by Buyckx and Tas [5], who also gave an account of spraying trials carried out with an Allouette helicopter. The application of 4 lb./acre of 2,4-D in 1 gal./acre of solution gave good control of the weed but, in this case also, complete eradication was not found possible with a single application.

The discovery of an entirely new herbicidal chemical, 1:1′ethylene 2:2′ dipyridylium dibromide was reported by Holmes [15]. This chemical gives a rapid kill of the aerial parts of a wide range of plants and is non-persistent. It has shown considerable promise for such purposes as potato haulm destruction, pre-harvest dessication of seed crops, as a directed weedkiller in cotton and sugar cane, and as a total herbicide, and is at present being widely tested in various parts of the world.

The final paper in this section by Bates [1] dealt with the problem of noxious weed legislation which, although difficult to enforce, is considered essential.

Papers Presented at the Conference

[1] G. R. Bates, Department of Research and Specialist Services, Southern Rhodesia. "Some aspects of noxious weeds legislation."

[2] G. R. Bates and J. B. Phipps, Department of Research and Specialist Services, Southern Rhodesia. "Water hyacinth (*Eichhornia crassipes*) and its control in Southern Rhodesia."

[3] L. B. Bjorking, Tanganyika Planting Co. Ltd., Tanganyika. "Weed Control at Arusha Chini Sugar Estate."

[4] G. E. Blackman, Department of Agriculture, Oxford, United Kingdom. "Differential spray retention and the selective action of herbicides."

[5] E. J. Buyckx and R. N. Tas, I.N.E.A.C., Yangambi, Belgian Congo. "Essais d'éradication de la jacinthe d'eau (*Eichhornia crassipes* Solms) a l'aide d'un hélicoptère a turbine."

[6] D. S. Byers and C. Parker, Colonial Development Corporation, Swaziland, and Fisons Pest Control Ltd., South Africa. "The use of pentachlorphenol for grass control in rice."

[7] W. B. Cleghorn and C. H. Cronin, Grasslands Research Station, Southern Rhodesia, and Fisons Pest Control Ltd., Central Africa. "Results of some arboricide trials in Southern Rhodesia."

[8] A. S. Crafts, University of California, U.S.A. "The formulation of herbicides."

[9] A. S. Crafts, "The uptake and distribution of herbicides in plants".

[10] C. H. Cronin, Fisons Pest Control Ltd., Central Africa. "The use of methyl bromide for the sterilization of seed-bed soils, with particular reference to its use in tobacco cultivation."

[11] S. D. Fleming, Fisons Pest Control Ltd., East Africa. "Perennial grasses as a limiting factor in tropical agriculture and methods for their control."

[12] J. D. Fryer, A.R.C. Unit of Experimental Agronomy, Oxford, United Kingdom. "The special problems of field experiments with selective herbicides."

[13] P. Gregory, Fisons Pest Control Ltd., East Africa. "The effect of mixtures of MCPA and 2,3,6-trichlorobenzoic acid on weeds and crops in East Africa."

[14] E. R. Hattingh, African Explosives and Chemical Industries Ltd., South Africa. "Weed problems and present control practices in South Africa."

[15] E. Holmes, Plant Protection Ltd., Engl d. "A new quaternary ammonium compound."

[16] G. W. Ivens, Colonial Pesticides Research Unit, Tanganyika. "Some tree and scrub problems in East Africa."

[17] G. W. Ivens, "Preliminary trials with Simazin as a pre-emergence herbicide in maize."

[18] G. W. Ivens, "The control of couch grass in coffee".

[19] C. Parker, Fisons Pest Control Ltd., South Africa. "Weed control in groundnuts with particular reference to MCPB and 2,4-DB."

[20] C. Parker and O. G. Ashby, Fisons Pest Control Ltd., South Africa. "Recent work on the control of weeds in maize."

[21] R. K. Pfeiffer and R. J. F. Burleigh, Fisons Pest Control Ltd., United Kingdom. "Experimental results with MCPA and 2,4-D in sorghum in the Sudan."

[22] D. M. Rocco, Naivasha, Kenya. "The use of activated DNBP and 2,4-DB for the control of weeds in lucerne."

[23] E. Rochecouste, Sugar Industry Research Institute, Mauritius. "Comparison of 2,4-D and MCPA for pre-emergence weed control in sugar cane."

[24] R. N. Tas, I.N.E.A.C., Yangambi, Belgian Congo. "La déstruction chimique de vieux bananiers."

[25] R. N. Tas, "L'éradication de *Paspalum conjugatum* dans les chemins de plantation."

[26] J. R. Tatterfield and C. H. Cronin, Gwebi Agricultural College, Southern Rhodesia and Fisons Pest Control Ltd., Central Africa. "The results of some selective herbicide trials in maize."

[27] O. West, Department of Research and Specialist Services, Southern Rhodesia. "The bush encroachment problem."

[28] K. Wilson-Jones, Colonial Pesticides Research Committee, London. "The weeding of cotton fallows in the Sudan."

[29] E. K. Woodford, A.R.C. Unit of Experimental Agronomy, Oxford, England. "The science and practice of chemical weed control."

HERBICIDES REFERRED TO IN THE TEXT

Abbreviated or Common Name	*Chemical Name*
2,3,6-TBA	2,3,6-trichlorobenzoic acid.
2,4-D	2,4-dichlorophenoxyacetic acid.
2,4-DB	4-(2,4-dichlorophenoxy) butyric acid.
2,4,5-T	2,4,5-trichlorophenoxyacetic acid.
Amino-triazole, Amizol or ATA	3-amino-1,2,4-triazole.
Ammate	ammonium sulphamate.
CP 1815	mixture of MCPA and 2,3,6-TBA.
Dalapon	2,2-dichloropropionic acid.
DNBP or Dinoseb	4,6-dinitro-o-sec-butylphenol.
F.B. 2	1:1′ethylene-2:2′dipyridylium dibromide.
MCPA	4-chloro-2-methylphenoxyacetic acid.
MCPB	4-(4-chloro-2-methylphenoxy) butyric acid.
PCP	Pentachlorophenol.
Simazin	2-chloro-4,6-bis(ethylamino)-s-triazine.
TCA	trichloroacetic acid.

REVIEW

HOW TO BUILD TO SIZE AND SHAPE, by A. E. S. Alcock, published by Longmans, Green & Co., London, 1958, pp. 62, price 5*s*. 3*d*.

This is one of the How to Build series which is intended for "those people in many parts of the world who build their own houses". Previous books in the series are How to Plan your Village, and How to Plan your Market, and those in preparation include Using the Plan, Setting Out, Construction, Finishing and Furnishing.

In this book the unit of measure is a man 6 ft. 6 in. tall when rooms are being designed for comfort and economy. The text is short and in simple language, most of the important points being explained by drawings. Six chapters cover the planning of the house, and the remaining six deal with the rules to be followed in building: shape, line, square, plumb and level. These are clearly explained, with many drawings to illustrate the right and wrong ways.

The simplicity and clarity of the style make this a most useful book for those who are trying to raise the standard of living in African agricultural areas.

D.W.D.

CAMBER BED CULTIVATION OF GROUND-WATER (VLEI) SOILS

I—EXPERIMENTAL CROP YIELDS

By J. B. D. Robinson, H. R. Evans and T. R. Brook, Department of Agriculture, Kenya

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The system of raised bed cultivation for clay soils with impeded drainage termed Camber Bed cultivation, has now been under trial at the Coffee Research Station, Ruiru, Kenya, for almost five years. In the previous paper (Robinson *et al.* 1955) the principles of this cultivation system were described in some detail, together with the method for carrying out the cultivation in the field. At the same time experimental yield data from a 2^3 factorial nitrogen × phosphorus × cattle manure trial which was cropped with maize (Yellow Durum) in the long rains, 1954, and with beans (White Haricot) in the short rains, 1954, were recorded and discussed in detail.

The original reason for investigating the cultivation of vlei soils was to determine whether these areas on coffee estates could be utilized for the economic production of Napier grass (*Pennisetum purpureum*) for mulching the coffee (*Coffea arabica*). The trial area previously described (Robinson, *et al. loc. cit.*) was planted to Napier grass during 1955 (*see* Plate I) and the yields obtained from the experiment during 1955, 1956 and 1957 are reported here.

Plate I.—Early establishment of Napier grass trial on Camber Beds (1955)

[*Photo by Shell*

At the same time as the original maize trial was planted a pineapple trial was put down on some adjacent Camber Beds (*see* Plate II) and yields from the plant and first ratoon crops are also reported here.

Plate II.—A general view of the Camber Bed cultivation trial area showing some of the Napier grass and the Pineapple plots (1956)

Experimental Details

Napier Grass Trial

This trial is a 2^3 factorial nitrogen × phosphorus × cattle manure trial with three replications and was planted in March, 1955, (early long rains period) with three eye "setts". The Camber Beds are 24 feet wide between the drain centres and the crop rows run along the length of the bed, with 5 feet between rows and 2 feet between each "sett" within the rows. In practice, continuous line planting with overlapping canes would be recommended but in this experiment individual "setts" were used to ensure a constant plant population in every plot. Each plot was 1/60th of an acre and was bounded on two sides by the bed drains; the plots in each of the three blocks were sited across, and not along, the length of the Camber Beds to enable major soil variations to be estimated, as far as possible, in the overall block differences.

The first application of ammonium sulphate (N treatment) was broadcast around the young shoots shortly after germination, at the rate of 2 cwt. per acre. This treatment was re-applied early in the short rains, 1955, to the young regrowth following the post-establishment cut. Further applications of ammonium sulphate, at the reduced rate of 1 cwt. per acre, were made early in the long and short rains of 1956 and 1957.

Double superphosphate (42-44 per cent P_2O_5, P treatment) was applied in the planting hole at the rate of 1 cwt. per acre and was subsequently broadcast at the same rate, on top of the Napier grass stools early in the long rains, 1956 and 1957.

The initial cattle manure application (C treatment) was put on at the rate of 10 tons per acre, broadcast over the bed surface before planting and lightly forked in; subsequently, a further dressing at the rate of 10 tons per acre was broadcast between the Napier grass stools, pre-long rains, 1957, and was again lightly forked into the topsoil.

The crop was cut at ground level by hand after each rains period when the tips of the leaves were turning brown because of soil moisture shortage. This corresponds to the usual time when mulch grasses are cut. The grass was weighed green in the field and representative samples were collected for dry matter determination.

In the dry weather, between harvesting and the onset of the next rains, a light hand forking was carried out to control weed growth and to open up the topsoil. On a large area of Camber Beds this operation is readily mechanized by inter-row cultivation with a disc harrow or rotary cultivator.

Pineapple Trial

The trial was planted in March, 1954, during the early long rains season and was also a 2^3 factorial design with four replications. There were 80 plants per plot and each plot extended from bed drain to bed drain and contained four double rows. The spacing was 1 foot between the plants, 2 feet between rows and 3 feet between the double rows which ran along the length of the beds; the plant population on an acre basis was 14,520 and fruit crowns were used as planting material. The Camber Bed cultivation for this trial was

carried out at the same time as that for the Napier grass trial.

Treatments were 0 and 10 cwt. ammonium sulphate per acre (N treatment) 0 and 4 cwt. single superphosphate per acre (P treatment) and 0 and 10 tons of cattle manure per acre (C treatment). The superphosphate and cattle manure were applied before planting. The superphosphate was placed in the planting hole immediately below the fruit crowns and the cattle manure was broadcast and forked into the soil. Ammonium sulphate was applied in two lots of 5 cwt. each. The first application was made two months after planting and was broadcast in a circle as near to the base of the plants as possible. The second application was made nine months later or 12 months after planting, but before flowering had commenced. In this application the sulphate of ammonia was placed in the base leaves of the plants.

Crop recording was carried out as the fruit became ripe, each fruit being weighed separately. Following the production of sucker and slip growths, excess growth were removed so that only one sucker per plant remained. Sucker removal was practised wherever surplus shoots arose.

Weeding was carried out by hand whenever necessary. Weeds, however, did not present any great problem after the first year due to the fact that the close spacing of the plants soon produced an almost complete ground cover which suppressed weed growth very considerably.

The rainfall during the trial period was:—

March to December, 1954	=	33.9 in.
January to December, 1955	=	31.4 in.
January to December, 1956	=	37.0 in.
January to October, 1957	=	48.4 in.

Yield Results

Napier Grass Trial

The overall mean yields of dry matter are given in Table I together with the equivalent weight of green material, both on an acre basis. In addition to the direct responses to treatments in the year of application, the yields will also reflect cumulative residual treatment effects, and in particular, the 1955 results will be made up of residual responses to the N.P.C. treatments applied to the maize and bean crops in 1954 (Robinson, *et al.*).

The nitrogen and phosphorus fertilizers have raised the overall mean yields substantially as has the application of cattle manure and the individual effects appear, generally speaking, to be additive. The exception to this is the probable interaction of the nitrogen and the phosphorus fertilizer treatments which just fails to reach the level of significance. A comparison of untreated control, and N + P treated crops as they appeared in the field is illustrated in Plates III and IV which were taken at the end of the long rains, 1956.

Table I.—Napier Grass Yields† and Treatment Effects§ on Camber Beds (Tons per Acre)

Treatment	Yield		Treatment Effects	
	Dry Matter	Green Matter	Dry Matter	Green Matter
(1)	1·45	6·44	—	—
N	1·67	7·42	†0·57**	†2·53
P	1·94	8·62	†0·85***	†3·77
C	2·50	11·11	†0·95***	†4·22
NP	3·16	14·04	†0·31	†1·37
NC	2·79	12·40	NS	
PC	3·09	13·73	NS	
NPC	3·63	16·13	NS	
L.S.D.'s‡	0·63*; 0·88**; 1·22***		0·32*; 0·44**; 0·61***	

Notes—

†Means of 18 i.e. average yield per season for 6 seasons.

§Difference between means of 72.

‡L.S.D.'s refer to dry matter figures only.

Most of the overall mean seasonal treatment yields in Table I are rather low in comparison with Napier grass yields on the shallow Kikuyu red loam soils over the same period, e.g. an overall seasonal mean of 3.2 tons of dry matter per acre was recorded for the control, untreated, plots in a nearby trial on established Napier grass. This comparison emphasizes the value of the cattle manure (C), the nitrogen + phosphorus fertilizer (N + P) and the N + P + C treatments in this trial to obtain reasonable yields. However, the low values in Table I may also be attributed in part, to the low yields of the post-establishment crop and to the low yields contributed by the short rains, 1957, crop. The yields of the short rains, 1957, crop, were low because it was a year of abnormally heavy rainfall (58.7 inches, average about 36 inches) and one in which the short rains were particularly abundant. This leads to poor aeration of the soil with water standing in the bed drains. Soil moisture measurements made in January, 1958, showed that there had been an appreciable loss of soil structure from the base of the cultivation depth, upwards in the bed profile.

Plate III.—Post-Long Rains, 1956, Napier Grass in a control plot (Pole is 10 ft. tall)

Plate IV.—Post-Long Rains, 1956, Napier grass in a N + P fertilizer plot (Pole is 10 ft. tall)

TABLE II.—MEAN TREATMENT YIELDS IN INDIVIDUAL SEASONS*, OVERALL SEASONAL MEANS† AND RAINFALL

(*Yield in tons per acre; rainfall in inches*)

TREATMENTS	SEASONS											
	L.R. '55		S.R. '55		L.R. '56		S.R. '56		L.R. '57		S.R. '57	
	1	2	1	2	1	2	1	2	1	2	1	2
(1)	0·36	1·90	1·66	7·76	1·60	8·69	1·32	5·08	1·10	5·29	2·68	9·05
N	0·55	2·91	2·05	9·58	2·01	10·92	1·63	6·27	1·00	4·81	2·78	9·39
P	1·80	9·32	2·37	11·07	2·10	11·41	1·83	7·03	1·36	6·54	2·16	7·30
C	1·46	7·72	2·90	13·55	2·73	14·84	2·00	7·69	3·29	15·82	2·60	8·78
NP ..	1·83	9·68	3·60	16·82	4·58	24·89	2·55	9·81	3·06	14·71	3·36	11·35
NC ..	1·24	6·56	3·20	14·95	3·62	19·6	2·43	9·35	4·06	19·52	2·21	7·47
PC	2·66	14·07	3·61	16·87	3·05	16·57	2·57	9·88	3·49	16·78	3·13	10·57
NPC ..	2·79	14·76	4·06	18·97	4·80	24·46	2·76	10·61	4·58	22·01	2·79	9·43
Mean ..	1·58	8·35	2·93	13·69	3·06	16·63	2·13	8·19	2·74	13·17	2·71	9.15
Rainfall ..	14·5		11·8		17·2		7·6		29·7		20·7	

NOTES—

*Means of 3 replicates; †Means of 24 replicates.

1, Yield of Dry Matter and 2, Yield of Green Matter.

L.S.D.'s (for Dry Matter figures only):

Means of 3 = 0·78*; 1·03** Tons of Dry Matter per acre.

Means of 24 = 0·27*; 0·36** Tons of Dry Matter per acre.

A consideration of the yield results in Table II brings out a number of important effects which are masked in the overall mean figures in Table I. The phosphorus fertilizer, when placed below the setts at the time of planting, assisted in a rapid and vigorous establishment whereas the nitrogen fertilizer produced only a very small and non-significant increase in the yield of the post establishment crop (long rains, 1955, figures). The cattle manure treatment also had a considerable effect on the post-establishment crop yield. In subsequent crops all these treatments have resulted in significant yield increases.

The interaction of the nitrogen and phosphorus fertilizers is negligible during the establishment period although an appreciable positive interaction was observed in some of the subsequent crops.

The contrast in yields between the long and the short rains in both 1956 and 1957 is much greater for green matter than for dry matter. The dry matter content of the Napier grass at the time of harvest was higher in the short rains crops than in the long rains crops, despite the fact that the long rains crops were taller and "older" than the short rains crops in terms of growing time. The effect is attributed primarily to the hot dry sunny weather and low atmospheric humidity prevailing after the short rains whereas following the long rains the weather is considerably duller. The importance of comparing these yields in terms of dry matter is thus emphasized, the overall mean season yields for the long rains and short rains, 1957, crops, on a dry matter basis, show no significant difference whereas it seems probable that, had the comparison been made on a green matter basis, a significant seasonal difference would have been found. For purposes of mulching in coffee, yield of dry matter is the important figure.

Pineapple Trial

This trial covered a period of 43 months. The time taken to produce the plant crop, from planting to final harvest, was 28 months. The first picking was made 22 months after planting. The time taken to produce the first ratoon crop from the final harvest of the plant crop to the final harvest of the first ratoon crop was 15 months.

A summary of the yield results is presented in Table III and shows the favourable influence of all the treatments, except the phosphate, over the two crops. Yield values, by virtue of the increased production of fruits of 4 lb. and over, i.e. first-grade fruits, were greatly influenced by the nitrogen fertilizer and cattle manure treatments, but not by the phosphorus fertilizer treatment.

Table IV shows the calculated effects of the treatments that were statistically significant. The nitrogen fertilizer increased the yield per acre and also the mean fruit weight in the plant crop whereas in the ratoon crop there was also an increase in the number of plants producing fruits. While the yield increase from this treatment was only just significant in the plant crop the increase was very highly significant in the ratoon crop. The increase in yield in the ratoon crop is, however, also associated with the increased number of fruits which were produced as well as with the increased fruit weight.

TABLE III.—PINEAPPLE BEDS (MEANS OF 4)

Treatments	Plant Crop				First Ratoon Crop			
	A	B	C	D	A	B	C	D
(1)	22·7	3·72	13,575	38·0	16·5	3·18	11,072	11·0
N	26·4	4·18	13,856	65·0	22·5	3·63	13,431	21·0
P	23·6	3·92	13,756	47·0	16·4	3·32	11,072	15·0
C	27·2	4·19	14,520	61·0	20·4	3·48	13,250	26·0
NP	26·3	4·17	14,118	64·0	20·3	3·36	13,250	15·0
NC	28·1	4·41	14,140	67·0	22·8	3·73	13,613	24·0
PC	28·2	4·43	14,128	77·0	20·1	3·56	12,705	33·0
NPC	28·6	4·53	14,118	80·0	21·8	3·71	13,431	29·0
L.S.D.'s	2·63* 3·58** 4·83***	0·20* 0·28** 0·38***	— — —	— — —	2·74* 3·74** 5·04***	0·39* — —	1,283* 1,746** 2,358***	

NOTES—

A—Yields, Tons per acre.
B—Average fruit weight in lb.
C—Number fruit per acre.
D—Percenatge of fruits 4 lb. and over.

TABLE IV.—PINEAPPLES ON CAMBER BEDS—TREATMENT EFFECTS (MEANS OF 16)

Treatments	Yields (Tons/acre)		Average Fruit Weight (lb.)		Number of Fruits/acre	
	Plant Crop	Ratoon Crop	Plant Crop	Ratoon Crop	Plant Crop	Ratoon Crop
N	+1·89	+3·49	+0·26	+0·26	—	+1,416
C	+3·38	+2·34	+0·39	+0·25	—	+998
L.S.D.'s	1·58* 2·09** 2·82***	1·38* 1·87** 2·53***	0·10* 0·14** 0·19***	0·17* 0·23** 0·39***	— — —	544* 744** 1,016***

The cattle manure treatment had a very highly significant overall effect on both the plant and the ratoon crop yields. This treatment significantly increased the mean fruit weight of the plant crop: the residual effect of this treatment increased the overall yield of the ratoon crop significantly by increasing both the mean fruit weight and the number of plants producing fruits.

Figure 1 shows the cumulative percentages of fruit harvested month by month from the control, nitrogen and cattle manure treatments. In the plant crop, cattle manure not only accelerated fruiting in the first two months of the harvest period, but, over the whole period, produced an increase in the total number of fruits harvested (100 per cent in four months compared to 84 per cent from the control up to that time). The nitrogen fertilizer treatment also produced a slight increase in the total number of fruits harvested and reduced the harvest period by one month relative to the control treatment.

In the ratoon crop the harvest period was more prolonged than in the plant crop, with the nitrogen fertilizer having the greatest influence on increasing the number of fruits harvested throughout the period. Both the nitrogen fertilizer and the cattle manure treatments resulted in a considerable increase in the total number of fruits harvested in this crop.

The value of accelerated fruiting which occurred in both crops (the bulk of the ratoon crop from the N treatments was off by July-August), lies in the fact that, if the greater part of a crop can be harvested before the cold season, i.e. July to September, losses due to "Black Spot" or "Black Heart" disease are minimized. Accelerated harvesting also reduces costs which are high if crops ripen slowly and irregularly. Accelerated harvesting also reduces the length of the cycle which in turn increases the economic potential of pineapple growing. In this trial the cycle was 43 months whereas on a red murram soil trial the cycle was 51 months.

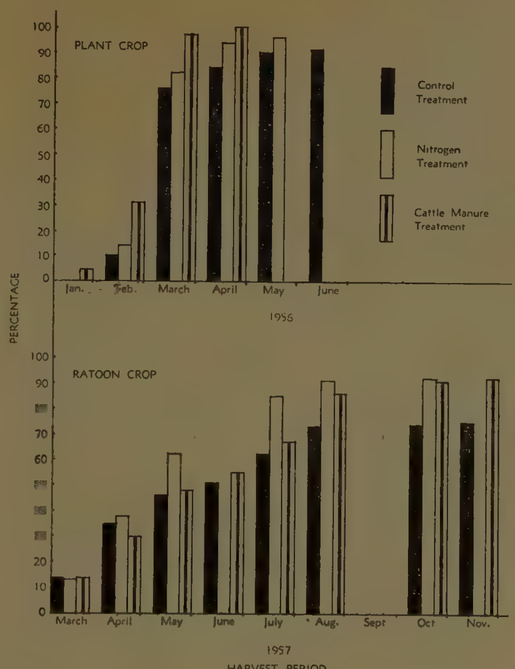


Fig. 1.—Cumulative percentages of Fruits harvested month by month (means of 3)

DISCUSSION

The results obtained in the Napier grass trial support the utilization of ground-water (vlei) soil areas for the production of mulch material on those coffee estates with an insufficient acreage of shallow red soil. It is essential to cultivate the land on the Camber Bed principle as described previously (Robinson, *et al.*, 1955) for this purpose.

In this particular trial, carried out on a typical vlei soil area which is situated in a depression between two ridges of Kikuyu red loam coffee soil, substantial yield responses were obtained to nitrogen and phosphorus fertilizers and to cattle manure. Additive effects of combined treatments on yield were obtained except with the two fertilizers. Nitrogen plus phosphorus fertilizers in the form and at the rates applied, sometimes interacted together in a positive manner producing larger yields than could be expected by adding the two single treatment responses together.

For establishing the crop initially phosphorus fertilizer placed in the planting furrow and or cattle manure was very advantageous and is to be recommended for establishing plantings on these soils after suitable cultivation. It is probable that in place of 10 tons per acre of cattle manure broadcast over the bed surface, 5 tons per acre of cattle manure (short) placed in the planting furrow, would have an equally good effect.

When a supply of cattle manure is available on a coffee estate it should be allocated to the Napier grass crop grown on vlei soils under this system of cultivation, as well as to the coffee areas with only a shallow residual topsoil (the result of sheet erosion and soil creep in the past), and in preference to coffee areas with a good depth of rich dark topsoil, i.e. on the Kikuyu red loam soil with 10 to 14 inches of dark red-brown topsoil. On the heavier clay vlei soils, a cattle manure dressing lightly forked into the topsoil probably assists in keeping the soil surface open and aerated, in addition to the benefits of added plant foods.

In the absence of a supply of cattle manure, established Napier grass should receive 1 cwt. per acre of ammonium sulphate plus 1 cwt. per acre of superphosphate fertilizer in the long rains each year to ensure reasonable yields. The very best results have been obtained in this experiment by combining alternate year dressings of cattle manure with fertilizer application in the long rains. Nitrogen fertilizer was also applied during the short rains in this experiment, but on an economic basis this treatment could probably be omitted without a very marked decrease in the short rain yields, particularly in years of poor rainfall.

As in the pineapple trial, the slope of the shoulders of the Camber Beds in this trial were too gentle and resulted in a noticeable edge effect on the outside rows of the Napier grass because of temporary waterlogging which occurred during periods of heavy and sustained rainfall.

The yield results of the Pineapple Trial show that this vlei soil when cultivated into Camber Beds, is capable of producing yields equal to, or even greater than, the red lateritic loam and murram soils (Kikuyu Soil Association) which were planted originally to this crop.

The total yield increase of the plant plus the ratoon pineapple crops to the ammonium sulphate and cattle manure treatments, was +5.38 and +5.72 tons per acre respectively. These responses were worth a total gross profit of Sh. 646 and Sh. 652 per acre respectively; after deducting the cost of the ammonium sulphate fertilizer (Sh. 292 per acre) and the cattle manure dressing (Sh. 400 per acre) but ignoring the cost of application in each case, the apparent overall net profit is Sh. 354 per acre for the ammonium sulphate treatment and Sh. 252 per acre for the cattle manure. Ammonium sulphate being easier to transport and apply is likely to be the more practical, under field conditions. Moreover, for large acreages, cattle manure is unlikely to be available in sufficient quantity. There would be no advantage in applying both these treatments to the same crop (*see* N + C Yields in Table III).

The value of these treatments lies not only in the total weight of crop harvested but also in the size of the fruits. Pineapples are purchased by canneries on a graded system of 1, 2 and 3 grades. Table III shows that the percentage of Grade I fruit, i.e. 4 lb. and over, produced from the ammonium sulphate and the cattle manure treatments was almost 100 per cent more than the control treatment in the plant crop and almost 10 per cent in the ratoon crop.

Yields in this trial would have been higher had the beds been constructed with sharper shoulders to the bed drains, thus ensuring a well-drained zone within the root range of the plants at the edge of the beds during periods of sustained rainfall. This aspect of the cultivation system is discussed in Part II of this paper. The beds used in the trial accommodated eight rows of pineapples, but occasionally two rows of plants on either side of the beds became temporarily waterlogged

during rainy seasons and the plants suffered suppression which became more marked during the ratoon crop cycle.

Because of the promising early results shown by this trial, considerable pineapple plantings on vlei soils, and on "Black Cotton" type soils, have since taken place. Because of the large acreages of both these types of soil which exist in the Thika pineapple-growing district of Kenya, larger acreages have now become available for the pineapple crop than were previously anticipated.

Summary

Ground-water (vlei) soils are capable of producing both Napier grass for mulching coffee and good pineapple crops, when cultivated on the Camber Bed system as previously described (Robinson, *et al.*, 1955).

For the establishment of Napier grass plantings on these soils it has been shown that 1 cwt. per acre of double superphosphate (42-44 per cent P_2O_5) placed in the planting furrow is very beneficial. Alternatively, 10 tons per acre of cattle manure broadcast over the beds before planting, has given almost equally good results. When establishing this crop on these soils it is recommended that one or the other of these treatments should be applied; if both of these treatments are applied at this stage the post-establishment crop yield will be greater than when either one is applied alone.

Yields of established Napier grass have been substantially increased by application of nitrogen and phosphorus fertilizers and by cattle manure. The effect of combining these treatments has been an additive one except where the two fertilizers were applied together. In this case the fertilizer combination treatment has resulted in yields which are significantly higher than the sum of the individual treatment yield increases, in some seasons.

On the basis of these results it is recommended that either ammonium sulphate plus double superphosphate, each at 1 cwt. per acre, or cattle manure at the rate of 10 tons per acre broadcast in alternate years over the bed surface, should be applied in the early long rains. For optimum yields both of these recommendations should be carried out.

Nitrogen in the form of ammonium sulphate at the rate of 10 cwts. per acre substantially increased the yield of pineapples on a virgin, ground-water (vlei) soil over a two crop cycle, by +5.38 tons per acre. Mean fruit weight and the number of plants producing fruits was also increased. Fruit maturity was accelerated and the period of harvesting the major proportion of crop was reduced.

Cattle manure at 10 tons per acre increased the yield of pineapples over the two crops by +5.72 tons per acre. This was a slightly heavier yield than from the ammonium sulphate treatment but the cattle manure is not only likely to be more expensive, but less practicable for field application over large acreages. Cattle manure also increased the number of plants producing fruits and the mean weight per fruit. The application of 4 cwt. per acre of single super-phosphate had no significant effect on yields.

It appears probable to us from the results obtained in these trials that the Camber Bed cultivation system as developed for vlei soils might be extended to other types of soil, i.e. black cracking clay or "Black Cotton" soils.

It also seems probable that crops other than those mentioned in this and the previous paper, e.g. leys, sisal, sugar-cane and horticultural crops, could be grown successfully under this system of cultivation.

Reference

Robinson, J. B. D., Brook, T. R., and de Vink, H. H. J. (1955). A cultivation System for Ground-water (Vlei) Soils. *E. Afr. agric. J.*, *21*, 69.

CAMBER BED CULTIVATION OF GROUND-WATER (VLEI) SOILS

II—MODIFICATIONS OF THE SYSTEM

By T. R. Brook and J. B. D. Robinson, Department of Agriculture, Kenya

(*Received for publication on 27th August, 1958*)

Since the publication of a description of the camber-bed system of cultivation of vlei soils (Robinson *et al.* 1955), a considerable area of vlei land has been treated in this way, and the experience gained brought out points which required further investigation. Observations during the past two years have shown that the run-off from camber beds can be very high, and it is clear that before the system is put into operation the area should be examined to see if the run-off can be safely discharged into protected drainage ways without risk of damage to roads, culverts, cultivated land etc.

In order to test these observations, a six-inch Parshall flume and a recording run-off gauge were installed at the Coffee Research Station, Ruiru, on a camber bed 30 feet wide and 566 feet long, with a fall of 1.15 feet.

During the period 5th April to 5th May the rainfall was fairly light, with low intensity, and run-off was so small that it was not recorded, the total rainfall being 9.39 inches in 18 days. From 6th to 16th May, however, 14.84 inches of rain fell in 11 days, sometimes with considerable intensity, and the data in Table I were recorded.

From 13th to 16th May, there was a constant flow which was just too low to be recorded, but it was estimated at about 1,500 gallons a day. If this flow is taken into account the percentage run-off is increased to 100 per cent over the greater part of this period. Even discounting this unrecorded flow, it will be seen from the table that the run-off can be as high as 90 per cent.

The bed was planted with haricot beans, giving a light cover, and the surface was rather "cloddy"; the furrow was clean and regular. It will be noted that the rainfall intensities during the period were quite low, but the calculated time of concentration on this particular bed is about 10 minutes, which means that given a fall of one inch in ten minutes, which is quite possible, the run-off from an almost saturated bed could be:—

0.38 acre × 90 per cent run-off × 6 in./hr. intensity = 2.05 cusecs.

This shows that if large areas of vlei land in a catchment are developed without first investigating the volume of run-off at peak periods, then flash floods could cause serious damage. Thus most of the areas being developed must have the run-off restricted to a safe level, and the simplest way to do this is to insert a pipe 2½ to 3 inches in diameter through a bund blocking the furrow outlet, as shown in Plate I. A three-inch pipe should be capable of removing a fall of six inches of rain within 24 hours and should thus prevent flash flows.

Since the restriction by the bund causes temporary ponding, it is essential that the surplus water should be kept as much as possible to the furrow and off the planted area. In order

TABLE I

Date	Rainfall (in.)	Duration of rain (hours)	Maximum Intensity		Maximum discharge (cusecs)	Run-off as percentage rainfall
			Peak period (in./min.)	Rate in./hr.		
6th May (a.m.)	0·54	—	—	—	0·046	18
6th May (p.m.)	0·77	3	0·50/15	2·00	0·050	22·6
7th May	3·00	7	0·33/15	1·32	0·280	58
8th May	0·16	5	—	—	—	—
9th May	1·76	4	0·60/36	1·00	0·275	69
10th May	0·06	3	—	—	—	—
11th May	0·35	16	—	—	—	—
12th May	1·72	15	0·18/10	1·08	0·236	50
13th May	4·64	18·6	1·00/40	1·50	0·275	90
14th/15th May	0·89	11	0·25/20	0·75	0·150	84
16th May	0·95	13	0·50/120	0·25	0·050	58

to do this the grade of the furrow should be laid as low as is possible while maintaining efficient drainage, otherwise overtopping of the outlet end of the furrow may occur.

A disadvantage of this ponding is that the rising and falling water table will probably cause more rapid deterioration of the soil structure of the camber bed, and re-ripping and aerating will be required more frequently than with a free-draining and unrestricted bed. However, the bunding has the advantage that costs are reduced by the fact that smaller outlet drains are required because of reduction of run-off.

Modified Construction of Camber Beds

As was stated by Robinson *et al.* (1955), the sequence of construction is:—

Survey.

Planning and lay-out.

Ploughing, ripping and shaping.

Construction of outlet drains.

As a result of the experience gained since then it is now possible to discuss some of these stages more fully.

Survey

On many vlei areas it will be found that the clay layer which is capable of development is associated with a murram zone which is very limited in its agricultural use. It is therefore highly advisable to test the depth of the clay by auger or by the soil probe method (Robinson *et al.* 1954) before a topographical survey of the area is made. A depth of two feet of clay is considered to be the minimum for agricultural development. In the survey itself the plane table has proved to be the most useful method, contours usually being plotted at vertical intervals of one foot, although on flat land it has sometimes been necessary to plot contours at intervals as small as three inches in order to obtain sufficient accuracy for planning.

It may be noted in passing that termite mounds are infrequent, and sometimes completely absent from, clay areas, but they are common in the murram areas and in those with better surface drainage.

Planning and Lay-out

In planning the following points should be considered:—

Access facilities.

Bed grades required.

Length of bed.

Width of bed.

Access is possible only in the dry season unless the roads are metalled, and work must be planned accordingly. In some schemes the retaining bund has been enlarged and used as a road, as is seen in Plate I. If this is done the bund or road should be at least six inches higher than the crest of the bed in order to ensure against overtopping.

Plate I.—Restricted run-off from camber bed area. Note pipe let into bund

The grade of the bed in an unrestricted layout, in which no retaining bund is used, should not exceed 1 in 300, since erosion takes place at a velocity of 1.8 to 2 feet per second on this type of soil. Plate II shows how erosion may occur on a grade of 1 in 200.

Plate II.—Erosion on a grade of only 1 : 200 with a resultant silt bank where the grade levels off

Where the lay-out is restricted, in that a retaining bund is built to form a reservoir area, the optimum grade is about 1 in 1,000, but in practice grades between 1 in 500 and 1 in 1,200 should be satisfactory. When the steeper of these grades is used it may be necessary to prevent over-topping by raising the bund above the level of the crest of the bed, as is done when it is used as a road.

The bed should be as long as is feasible, with a maximum of about 1,800 feet, in order to reduce the cost of construction, to reduce the number of outlet pipes to a minimum, and to facilitate cultivation and maintenance.

The width of the bed determines the amount of land which is occupied by furrows and hence is lost to cultivation. On this account it is desirable to make the bed as wide as possible, but it must not be so wide that the surface drainage is impeded. Experiments are in progress to find the optimum width, but until more information is available on this point it is considered that for safety the width should not exceed 30 feet.

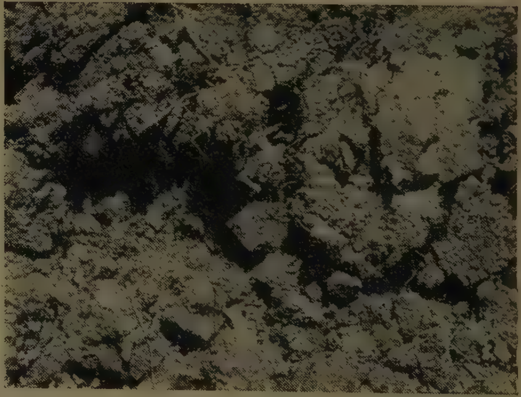
Ploughing and Ripping

Ploughing after marking out the beds should present little difficulty, and a small crawler-type tractor has been found most suitable for this work, although it can be done with a fairly high-powered wheel tractor. Ploughing should be done when the soil is dry, in order to avoid compaction and also to eradicate any couch grass (*Digitaria scalarum*) which may be present. This latter point is most important, for the eradication of couch from made beds is a formidable and expensive task. The land should not be ploughed when there are any ponds or puddles on it, and if these are extensive or numerous it may be necessary to assist drying out, or to canalize any spring flow, by constructing a temporary system of shallow drains, usually on the herringbone principle.

Ripping is a most important operation which can have a very persistent depressing effect on crop yields if it is carried out at the wrong time. It should be done when the ground is dry and when the ripper tines cause a marked upheaval with lateral cracking. Plates III and IV show the effect which ripping should have on the soil structure. A useful guide is that if the ripper cuts "like a knife through butter" the operation should be stopped immediately, for the soil is obviously too moist. The effect of a ripper tine on wet clay is to form by pressure a deep channel with relatively impervious sides and bottom, which may subsequently fill with water and produce a perched water table on the bed itself, the very condition which the camber bed is designed to avoid. Plates V and VI show the effect on the soil when ripping is carried out on a wet soil. A further point is that the compaction caused by the tractor and the wheels of the implement is highly undesirable.

Shaping of the Bed

It has been noted that where the side slopes of the ditches are shallow then a marked depressing effect on the crop is liable to occur along the edge of the planted area contiguous to the ditch. This can be particularly noticeable in pineapples which require good drainage.



Plates III and IV.—Examples of the marked disruption of the clay soil after ripping. This is the condition required

Plate V.—Showing the most undesirable effect of ripping in too moist a soil

Plate VI.—Showing soil conditions too wet to work. Note ineffective ripping followed by one grading cut each side. Crop results from this completed bed have been extremely poor. Further ripping is required if and when the bed has dried out sufficiently for this to be done effectively

When the side slopes are too steep then erosion quickly cuts into them and occasionally erosion furrows across the bed are evident. The cross section recommended is as shown in Figure 1.

Erosion of side slopes is always liable to occur so ditch capacity may have to be maintained by occasional cleaning out or controlled by grassing the side slopes. *Paspalum notatum* would be recommended for this purpose.

Some Observations on Camber Beds and their Construction

So far the shaping of Camber Beds has been done here by using a D7 or TD18 tractor and a No. 2 Preco Grader. Although the grader moves the earth laterally quite satisfactorily it is not particularly efficient in excavating in the ditch itself. Trials are being made with different forms of ditching machinery in an effort to reduce the number of cuts required to an absolute minimum and thereby to reduce the compacting effect which is so undesirable on these clay soils; and also, which is most important, to reduce the costs which are at present rather high.

The shorter the length of bed the higher the cost per acre. This is due to the time lost in turning, e.g., actual costs for a D 7 and No. 2 Preco Grader:—

Bed 30 feet wide—182 feet long, turning cost 28 per cent of total.

Bed 30 feet wide—650 feet long, turning cost 10 per cent of total.

A bed to the required specifications should be constructed in eight full rounds at an average speed of travel of 3.3 m.p.h., but much depends upon soil condition and the effectiveness of the initial ploughing.

It appears probable that after some undetermined period following construction, re-ripping of the beds will become necessary to aerate the soil and promote optimum drainage. At the Coffee Research Station this has now become necessary on those beds which have been under Napier grass for four years. The intervals between such ripping will depend upon the crop grown, its management, and restriction, if any.

Summary

The success, under proper management, of the Camber-Bed system opens new avenues of development in areas hitherto regarded as marginal. There is indication that it will be possible to produce food and profit from certain black cotton soils previously producing only grass, and that of doubtful quality, and low in quantity. The successful farming of such soils demands considerable skill and "feeling" for the soil.

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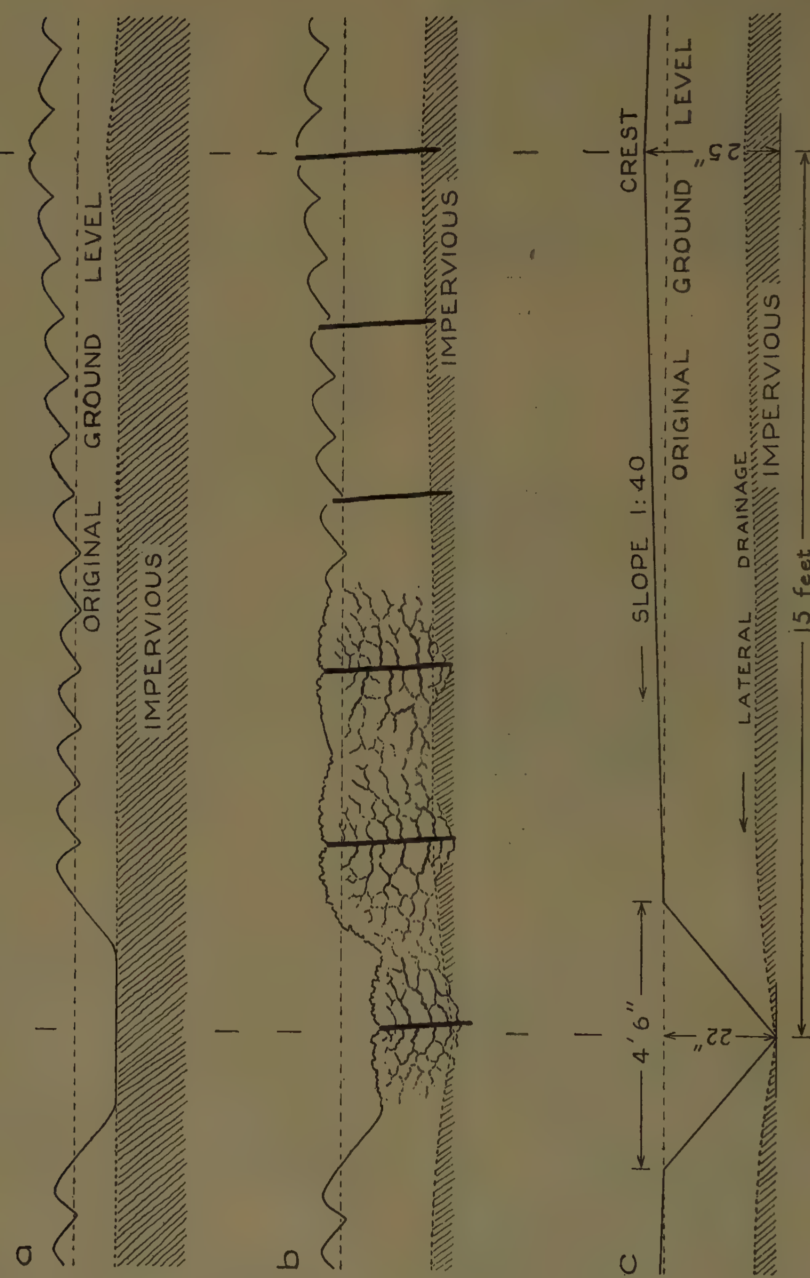

Figure 1.—Diagrammatic cross-section of one half of a 30-ft. wide camber bed

SOWING SEED IN POLYTHENE BAGS

By G. Watkins, Forest Department, Tanganyika

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The usual methods employed in East African nurseries for raising seedlings and transplants are well known and have been practised for many years. These methods all have certain inherent disadvantages. A simple technique of sowing seeds in polythene bags containing vermiculite seems to remove most of these disadvantages and promises to be very successful, especially in the case of medium size and large seeds.

The principles behind this new technique are similar to those used for the pre-germination of seed by stratification in sacks buried in moist sand. The polythene bags are, however, an improvement on hessian sacks, as although they allow air to pass through freely, they keep the bag contents moist for long periods.

Vermiculite, which replaces sand as the germinating medium, is a laminated micaceous material "exfoliating" or expanding to about 10 to 20 times its original volume when subjected to temperatures as high as 2,300 degrees F. This exfoliated material consists of countless tiny cells containing air, which account for its light weight. It is chemically inert, does not decompose or deteriorate and has excellent water-retaining properties. It is sold in various grades, these normally being coarse (3/16 in.), medium (⅛ in. to 3/16 in.) and ungraded. The coarse grade is recommended for polythene bag sowings, as its total air content of pore space plus cell space is considerably greater than that of the other grades. The ungraded vermiculite is unsuitable as a large proportion of it consists of fine dense particles which may not contain sufficient air for the germination of some species. Vermiculite is produced mainly in South Africa and some western states of the U.S.A., but the exfoliated material is now available from many gardening shops throughout the world.

When using this new method, seed is first given any special pre-sowing treatment, such as soaking or scarification, as is customary for the species being sown. It is also essential to remove all fleshy parts of fruit adhering to the seed coat whilst it is advisable to treat the seed with a fungicidal dressing as a precaution against possible fungal attack or rot.

The seed is then mixed with coarse grade vermiculite in proportions by volume of not less than one of seed to two of vermiculite. Water is added until the mixture is moist but not waterlogged and it is always better to err on the dry side rather than to make the mixture too wet. As a rough guide, one part of water to between four and six parts of vermiculite and seed mixture is sufficient to reach the required degree of moistness. Excess water should not be squeezed out as this tends to flatten the individual particles of vermiculite and reduce their efficiency in retaining water. Instead, the vermiculite can be dried off by leaving it exposed to the sun for a short period, or alternatively, dry vermiculite can be added and well mixed in to take up the excess moisture.

When ready, the moist vermiculite and seed mixture is placed in a polythene bag which is tied at the top to prevent drying out. For convenient handling a bag should not be larger than about 24 in. × 12 in. in size, and a bag of this size, when three-quarters full, can contain up to five lb. of coffee seed, for example, in addition to the vermiculite. When filled, the bag should be kept warm, although it should never be exposed to strong sun for any length of time as this may scorch and kill some of the outermost seed. Provided the polythene gauge is not too thin, the contents will remain moist for a long period. If there should be signs of drying out in the first few days, due to absorption of water from the vermiculite by the seed in the first stage of germination, a little water can be added and well mixed in the bag. Little other attention to the bag contents is required besides emptying once or twice weekly to see whether the seeds have commenced germination and to pick out and destroy any rotting seed. The latter are readily seen by the flakes of vermiculite which adhere to them, although in most species so far tested seed rot has been negligible with fresh and viable seed. With old seed containing a large proportion of bad seed, a cobwebby growth of mildew may appear on the surface of the vermiculite after a few days, but this can usually be controlled by mixing in a little fungicidal dressing. Thereafter, an occasional stirring will prevent this growth from accumulating and no great harm

will result. Seed not properly cleaned of its fleshy fruit coat may also give a similar mildew growth, and its control is as for old seed.

Depending on the species, the age of the seed, and the prevailing temperatures, germination will commence after a few days or weeks. Usually a small percentage only will have actually germinated on the first or second day after germination has commenced, and these can be ignored. Soon a much larger number of seed will be found with protruding radicles. These are then ready for the next stage, which is to select for "sowing-out" into the transplant trays or beds. Selection is best done by emptying the bag contents on to a sieve to separate the seed from the vermiculite; seeds with emergent radicles can easily be seen and they are placed in a separate bag to prevent drying while they await sowing-out. If the size of the seed makes hand-picking difficult during sorting, a pair of small forceps is recommended.

During this sorting-out process the opportunity should be taken to destroy any obviously rotten seed.

The germinated seeds are sown-out by hand or by tweezers, into prepared holes dibbled in the trays or beds. Normal sowing depths and transplant espacements are adopted, although if the radicles have grown to any length the dibble holes must be made deeper to receive them. The seeds are then covered with soil and firmed. If the covering soil is of a coarse or heavy nature the seedlings may find it difficult to push their way out of the soil, and in the process become deformed, or they may even fail to emerge at all. This can be easily prevented by covering the sown-out seed with a mixture of sand and moist vermiculite instead of soil. As vermiculite has excellent insulating properties this covering medium should later be of value by reducing the possibility of sun scorch to the root collars of the young seedlings in hot weather. Pure sand is unsuitable as it dries out too rapidly and is also likely to cause sun scorch.

It takes seedlings of some species only three to four days to break through the soil surface after being sown-out as seeds with emergent radicles, although some of the slower-growing species may take up to three weeks. A further week or so, and the seedlings are standing erect and can be considered as being fully established. Thereafter they are given exactly the same tending and attention as that given to young transplants, and they remain in the trays or beds until they are ready for taking out to their final planting site.

Seeds which have not germinated when the bag contents have been sieved for the first time need not be rejected. They do not all germinate on the same day, but follow instead a positively skewed curve of numbers plotted against time, usually spread over a few days or, in some cases, over a period of weeks or even months. Ungerminated seeds remaining after each sorting-out process should, therefore, be replaced in the bag together with the vermiculite so that germination may continue. For species with quick-growing radicles, the bag contents should be emptied daily or every second day once germination has begun. If possible this inspection should not be delayed for longer than two days, as many of the radicles will by then be up to nearly an inch in length, making sowing-out more difficult. For slower-growing species the inspection intervals can be longer, and every third or fourth day should be sufficient for such cases.

One objection that may arise against the raising of plants by this method is that, after sowing-out, the area covered by the boxes or beds may be quite extensive, and, until the seedlings have emerged and established themselves, they will all require as much tending as would the much smaller area taken up by the conventional seed beds. This problem, which involves keeping the boxes or beds in a continual state of moistness until the seedlings have emerged and are fully established, causes no difficulty in cool cloudy weather. If the weather is hot and sunny the difficulty can be overcome, to a large extent in the first instance, by mulching or box-stacking, and later, during the emergence of the seedlings, by shading. If for some reason this is not practicable, the following modified technique is available.

The seed is kept in a bag only until such time as germination is about to commence. The bag contents are then emptied on to a sieve to separate the seed from the vermiculite so that all the seed can be collected and sown into a seed bed in the normal way. As the seedlings appear, they are lifted for transplanting into boxes or beds as has been the usual practice. As will be noted, this alternative method does not eliminate seed beds completely, but it does reduce the time

necessary for seed to remain in them. The saving involved may be quite considerable; in the highlands of East Africa for instance, *Pinus radiata* usually takes three weeks between the date of sowing and the emergence of the first seedlings, but with partial germination in polythene/vermiculite first this is reduced to five or six days only.

It is not known whether this new method of keeping seed in polythene bags until they germinate will be a success with all species. For sowing-out of the germinated seed at transplant spacing, however, it is necessary for the seed to be large enough to be handled individually. This precludes the dust-like seed of such species as *Eucalyptus*, although preliminary tests with *Pyrethrum* indicate that small seed can be partly germinated in polythene/vermiculite and then sown together with the vermiculite into seed beds as soon as germination commences in the bags.

For many of the important plantation trees, however, and also for some agricultural crops, germination in polythene bags followed by sowing-out of seed with emergent radicles has proved to be a practical proposition on a field scale. With further experience it will, no doubt, be possible to improve and simplify the techniques even further, but present methods have already given satisfactory results on a field scale for *Pinus radiata, P. canariensis, Cedrela mexicana* and *Coffea arabica,* whilst small scale tests have been carried out successfully on over a dozen other species. As a general guide to germination rates and percentages obtainable from these particular species, a summary of all tests so far undertaken is given in Table I.

Advantages and Disadvantages of Seed Sowing in Polythene Bags

Some of the advantages claimed for sowing seed into polythene bags containing vermiculite are:—

(*a*) Complete elimination of seed beds in the case of seedlings which are normally transplanted, and ease of tending prior to sowing-out; weeding is unnecessary and watering reduced to a minimum.

(*b*) Germination rates can often be controlled to advantage by varying the temperatures where the bag is stored. Optimum temperatures will hasten germination, and it can be delayed or retarded by a drop in temperature.

(*c*) No elaborate equipment is necessary, as the only materials required are polythene bags and vermiculite. The first are easily obtainable in most places at a few pence each whilst vermiculite is also relatively cheap, a sack of 4 cubic feet costing in East Africa between Sh. 10 and Sh. 20 depending on the grade, the coarser grades being the most expensive. There is also no reason why the polythene bags cannot be used on a number of occasions, although after each set of sowings it is advisable to wash them out well with warm soapy water so as to kill any fungal spores that may otherwise introduce rot to future sowings. Vermiculite can also be used again if first sterilized by heating, although caution is advisable if previous sowings contained a large proportion of quick-rotting impurities.

(*d*) Sowing-out of germinated seed is considerably quicker than the transplanting of young seedlings, and even semi-skilled labourers soon become adept in the technique. Even if the radicles have been allowed to grow too long, sowing-out is still no more difficult than the handling of small seedlings during transplanting. The main faults encountered when first trying out this new method are to sow-out the seed too deeply if no dibbling board is used, and also to point some of the radicles upwards. After a little practice, however, these can be remedied.

(*e*) Seed is not exposed to pest damage when in the polythene bags. Insect pests can be easily controlled with insecticidal seed dressings, whilst rodents can be denied access to the bags. Admittedly attack can occur after sowing-out, but rodents can dig up only one seed at a time at transplant spacing and this is far less damaging than when a rodent gets into seed beds with high density sowings.

(*f*) Seed-rot can be controlled in the bags, as rotting seed can easily be seen by the vermiculite that accumulates around them. By removing and destroying such seed as soon as they are noticed, rotting can be kept in check. However, provided the seed is fairly fresh and is well cleaned of fleshy pulp and

TABLE I.—SUMMARY OF RESULTS

SPECIES	Age of seed	Seed per pound (approx.)	Maximum quantity placed per bag	Pre-sowing treatment	GERMINATION RESULTS (AT 60°–70° FAR.)				
					Commences after	Peak period	Per cent Peak	Completed after	Per cent Total
							per cent		*per cent*
1. *Acacia cyanophylla* . .	3 years	30,000	1 lb.	Boiling water	5 days	6th–20th day	50	8 weeks	81
2. *Acrocarpus fraxinifolius* . .	1½ years	12,500	4 oz.	24 hrs. warm water	6 days	Irregular		10 weeks	67
3. *Agathis robusta*	3 weeks	8,400	1 oz.	Nil	4 days	5th–7th day	53	11 days	61
4. *Azadiractha indica* . .	2 weeks	1,900	4 oz.	Nil	5 days	6th–10th day	58	26 days	70
5. *Cassia nodosa*	4 weeks	1,700	8 oz.	Scarification and 24 hrs. cold water	3 days	4th day	81	7 days	94
6. *Cedrela mexicana* . .	3 months	25,000	2 lb.	Nil	5 days	6th–8th day	59	13 days	72
7. *Ceiba pentandra*	2 weeks	4,300	8 oz.	Nil	5 days	5th day	41	7 days	49
8. *Coffea arabica*	3 months	1,600	6 lb.	Nil	18 days	21st–28th day	71	7 weeks	89
9. *Delonix regia*	1 year	800	4 oz.	Scarification and 48 hrs. cold water	4 days	5th–8th day	57	12 days	86
10. *Eriobotrya japonica* . .	2 weeks	300	4 oz.	Nil	14 days	16th day	56	24 days	100
11. *Eucalyptus ficifolia* . .	7 months	18,000	4 oz.	Nil	8 days	10th–13th day	31	21 days	37
12. *Machaerium tipu*	3 months	800	4 oz.	Nil	4 days	4th–6th day	73	14 days	94
13. *Maesopsis eminii*	3 months	500	2 lb.	Nil	5 weeks	7th–10th week	60	Still continuing	
14. *Pinus canariensis*	5 months	4,200	2 lb.	Nil	7 days	8th–12th day	60	18 days	86
15. *Pinus elliottii*	18 months	17,000	8 oz.	48 hrs. warm water	5 days	Irregular		16 weeks	59
16. *Pinus radiata*	6 months	12,500	2 lb.	Nil	7 days	11th–28th day	60	6 weeks	84
17. *Schinus molle*	2 weeks	8,000	8 oz.	12 hrs. cold water	5 days	6th–8th day	38	10 days	45
17. *Schinus molle*	2 months	11,000	8 oz.	12 hrs. cold water	14 days	16th–19th day	23	28 days	28

provided the vermiculite is not maintained in a waterlogged condition, rot should be negligible. For instance, in a coffee test with 1,000 seed, five only were found to be rotten in the course of six weeks, whereas losses in freshly collected *Pinus radiata* are usually below 1 per cent during the first few weeks.

(*g*) Damping-off losses are reduced. As polythene is impermeable to the spores of damping-off, the seeds are not attacked by this disease whilst in the bags. After sowing-out at transplant spacing, any damping-off that does occur cannot spread quickly owing to the wide spacing between the seedlings. In addition, the germinating seed with their short protruding radicles do not suffer the bruising on sowing-out to which young seedlings are subjected during transplanting and which so often provides an opening for fungal attack.

(*h*) When germination is sporadic and spread over a long period, seedlings have to be pricked-out individually from seed beds. Seed losses occur when seedlings are so lifted as it causes some of the non-germinated seed to be disturbed, burying them too deeply or leaving them exposed on the bed surface to dry out. This does not happen with polythene/vermiculite sowings.

(*i*) Because seed losses from various causes are reduced, plant yields to the pound of seed are generally higher than those obtainable from seed bed sowings. Reference to Table I will show the percentages that have been obtained for species so far tested by polythene/vermiculite. Taking the two Pines, *P. radiata* and *P. canariensis*, as examples, it will be noted that the yields to the pound of the former are equivalent to 7,500 after four weeks, or 10,500 in six weeks, and the latter, 2,500 after 12 days, or 3,600 in 18 days. Corresponding numbers even in the best nurseries seldom exceed 8,000 and 2,500 respectively, whilst yields of only half these amounts are not uncommon.

(*j*) For species such as coffee and the ornamental Cassias, which do not transplant easily and are thus best raised by sowing out directly into beds or boxes at transplant spacing, only seed which is actually known to have commenced germination is sown-out, and unless unfavourable conditions exist there is no reason why nearly a 100 per cent flush of seedlings should not be obtained.

(*k*) The saving of time due to the more rapid emergence of seedlings from germinated seed may result in quite a considerable reduction in nursery costs. Coffee seedlings, for example emerge at soil level in three weeks after sowing-out with germinated seed, which compares favourably with the usual period of six-seven weeks.

Some of the disadvantages of the method are:—

(*a*) As temperature is such an important factor, it is advisable to keep the bags in a warm place. This presents no problem in a warm area, but subordinate staff stationed in the colder climates may not have the facilities for doing this, and germination rates with them will be slower and more protracted.

(*b*) Once germination has begun, inspection and sowing-out of the germinated seeds cannot be neglected for any length of time and this is particularly so for the quicker-growing seedlings.

(*c*) After sowing-out, the boxes or beds containing the germinated seeds must be treated as one large seed bed until the seedlings appear above soil level and have passed the delicate stage. This is not a formidable task, if mulching, shading or box-stacking can be carried out, although with the latter the boxes must be unstacked as soon as the first seedlings begin to break through the soil surface so that they may have room to develop. With any delay in unstacking, the seedlings, failing to grow erect, will force themselves against the box above them and become etiolated in the process.

(*d*) If there is a plague of rats or birds, protection of the unstacked boxes or transplant beds is rendered difficult as the area to be protected is much larger than that covered by seed beds.

(*e*) If germination is not uniform in a species, sowing-out must be spread over the whole germination period, and this can be a decided disadvantage when small amounts of seed are involved. For large quantities this can be turned to advantage, e.g. for *Pinus radiata,* with the germination period extending over four or five weeks this obviates the need to stagger seed sowings.

(*f*) Inspection of the germinated seed may take time, and this is especially true of seed with protracted or low germinative capacity. Seedlings can be lifted in large batches from seed beds in a matter of seconds, but the sorting out of pre-germinated seed takes much longer. In the case of *Pinus canariensis,* 30 minutes can be spent in sorting out a pound of seed to yield approximately 1,000 seed ready for sowing out. This time can be easily made up later, however, when actually sowing-out the seed since this operation is far more rapid than the transplanting of seedlings.

Conclusion

The germination of seed in polythene bags containing vermiculite and the sowing-out of these seeds at transplant espacements has been successfully employed for many species. When trying out any species for the first time, however, it is wise to start with quantities on a germination test scale to ensure that the method is suitable for the particular species.

A considerable field of experimentation is still open: can vermiculite be dispensed with completely for some species? A few large hard-coated seeds have already been germinated in polythene bags containing no other sowing medium, although the seed required fairly frequent moistening by soaking and then draining away excess water. Other questions, such as the quantity of seed that can be placed in a single bag; the optimum temperatures; the best gauge of polythene, and the germination periods of various species have still to be accurately determined. Nevertheless, the methods which have been described in this article are known to give satisfactory results for the species discussed and in the quantities mentioned.

ACKNOWLEDGMENTS

I wish to express my gratitude to Mr. D. R. Johnston of Arusha School, Tanganyika, for reading through the manuscript and for his helpful suggestions and advice.

I should also like to thank Mr. Emilian Raphael, Forest Ranger, for assistance in much of the field work that was undertaken.

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REVIEW

THE UNITED STATES AND AFRICA, proceedings of the 13th American Assembly, Columbia University, Harriman, New York, June, 1958, pp. 252, price $1.00.

This report contains the papers read at the Assembly, along with its Final Report of findings and conclusions. The main headings are the character of American interest in Africa; the character and viability of African political systems; external political pressures on Africa today; the character and potential of African economies; the African economy and international trade; racial situations and issues in Africa; and culture and changing values in Africa. In addition there are 34 pages of statistical tables and maps.

D.W.D.

A COMPARISON BETWEEN RUSSIAN COMFREY AND LUCERNE

By R. Strange, Grassland Research Station, Department of Agriculture, Kenya

(*Received for publication on 5th June, 1958*)

A good deal of interest in Russian comfrey has been shown by Kenya farmers during the last few years, and it was therefore decided to obtain some information regarding the agricultural value of this plant at Kitale, where the altitude is 6,200 ft. and the soil is a free draining medium sandy loam. Lucerne was used as a "yardstick" as it competes with comfrey under these conditions.

Accordingly, a randomized block experiment with three replications was laid down at the Grassland Research Station in May, 1955, and was continued until March, 1957, a period of two full seasons. The treatments were:—

"Booborowie" lucerne (L0)—without fertilizer.

Russian comfrey (C0)—without fertilizer.

"Booborowie" lucerne (L1)—with annual dressings of 1½ cwt. an acre of triple superphosphate and 5 tons an acre of F.Y.M.

Russian comfrey (C1)—with manurial dressings as above.

In October, 1956, the plots were split for an application of gypsum (calcium sulphate) at 1½ cwt. an acre prior to the last three cuts of the experiment, as at that time there had been some evidence of a possible sulphur shortage in the Kitale soils, and it was desired to check this point.

The lucerne was established from seed in continuous lines 3 ft. apart, and the comfrey from roots at 3 ft. × 3 ft. spacing. The plots were kept clean weeded and the herbage was harvested simultaneously in all plots at intervals of about six weeks during the growing season. Rainfall, as shown in Table I, was about average for this locality.

The lucerne nodulated well but its growth was retarded by a probable sulphur shortage in the soil. The comfrey was infested with root eelworm and seems to be very susceptible to this pest. Furthermore, it was weakened by the plant parasite *Alectra* (?) *asperrima*, which did not attack the lucerne.

TABLE I—RAINFALL DURING EXPERIMENT

Month	1955	1956	1957
January	—	2·12	0·94
February	—	3·10	0·15
March	—	2·56	—
April	—	5·75	—
May	4·44	6·85	—
June	3·19	2·70	—
July	4·58	4·72	—
August	6·18	7·50	—
September ..	6·28	4·46	—
October	2·83	4·73	—
November ..	1·42	0·56	—
December ..	4·87	0·75	—
TOTAL ..	33·79	45·80	1·09

Owing to the hairiness of the leaves, soil contamination on the comfrey was considerably greater than on the lucerne. In one estimate, made after a period of rain, the amount of soil held on the cut material was found to be as given in Table II.

TABLE II—SOIL CONTAMINATION ON LUCERNE AND RUSSIAN COMFREY

(*per cent of dry matter*)

Species	Percentage of soil on the herbage
Lucerne	1·72
Comfrey	13·51

This factor, unless taken into account, gives a considerable bias in favour of the comfrey in yield comparisons with less hairy plants.

In addition to the foregoing considerations, Russian comfrey appears to have a number of other disadvantages when compared with lucerne. It is less convenient to establish; it is more difficult to cut and cure for hay; it is more difficult to cultivate and more susceptible to soil erosion, being established in single plants rather than in continuous lines; it is less palatable to cattle, especially when grazed *in situ;* it is said to be more difficult to plough out when finished with; and, being a non-leguminous plant, is less likely to have a beneficial effect on soil fertility than lucerne, which can fix nitrogen if conditions are suitable.

Single samples of each plant were analysed chemically in each of the two seasons, with the following results:—

TABLE III—ANALYSIS OF LUCERNE AND RUSSIAN COMFREY HERBAGE

(*per cent of dry matter*)

Ingredients	August, 1955		August, 1956	
	Lucerne	Comfrey	Lucerne	Comfrey
Ash	10·36	19·73	9·59	22·05
Crude Protein..	30·52	23·38	20·17	17·31
Ether extract ..	3·36	4·08	2·61	2·54
Crude fibre ..	27·76	9·90	19·90	12·61
Carbohydrate	28·00	42·91	47·73	45·49
Phosphorus ..	0·29	0·34	0·33	0·47
Calcium ..	1·43	1·35	0·96	1·56
Silica	—	—	0·67	5·78

The crude protein content of the lucerne is higher than that of the comfrey, but the latter is preferable in respect of its fibre content, which would favour it to some extent for feeding to pigs or poultry. The high silica content of the comfrey is not due to soil contamination as the samples had been washed prior to analysis.

The relative digestibility of the crude protein in these two plants, as determined by pepsin digestion (Wedemeyer method), was examined in the two samples of August, 1955, and is given in Table IV.

TABLE IV—COMPARATIVE DIGESTIBILITY OF CRUDE PROTEIN IN TWO SAMPLES OF LUCERNE AND RUSSIAN COMFREY

Species	% of C.P. in D.M.	% Digestibility of C.P.
Lucerne ...	30·52	92·27
Comfrey ..	23·38	53·25

According to information recently published by Glover, Duthie and French (1), the digestibility of crude protein normally rises with the increase in percentage of crude protein in the herbage. Therefore, in the case of this comparison, the lucerne protein with 30.52 per cent in the dry matter should be expected to be relatively more digestible than the comfrey protein with only 23.38 per cent crude protein in the dry matter. This does not fully account for the large difference between the two figures, however, as, allowing for this, the digestibility of the comfrey protein would have to be about 81 per cent in order to be comparable with that of the lucerne. It appears, therefore, that the protein of Russian comfrey is, in fact, appreciably less digestible than that of lucerne.

As shown in Table V, the dry matter content of comfrey herbage was found to be considerably lower than that of lucerne in all cuts throughout the experiment; the herbage was not harvested until dew or rain had dried off.

TABLE V—THE DRY MATTER CONTENT OF FRESH LUCERNE AND RUSSIAN COMFREY—MEAN OF ALL CUTS

Species	Percentage dry matter
Lucerne	24·9
Comfrey	14·2

In view of its low, dry-matter content, any yield figures for comfrey which are expressed on a basis of fresh material are apt to be very misleading. The yields obtained during the period of the experiment, on a dry-matter basis, are given in Table VI.

TABLE VI—MEAN DRY MATTER YIELD OF LUCERNE AND RUSSIAN COMFREY—WITHOUT GYPSUM

(*cwt. per acre*)

Season	Lucerne		Comfrey		S.E. of difference between means
	L0	L1	C0	C1	
1955 ..	34·53	43·60	34·53	37·87	±4·79
1956 ..	30·60	41·33	33·33	33·53	±4·89
Total ..	65·13	84·93	67·86	71·40	±3·02

These yields are not corrected for soil contamination, which was greater on the comfrey than on the lucerne, and which therefore gives a bias in favour of the comfrey.

The differences during each of the two seasons were not significant, but the L1 treatment (Lucerne plus fertilizer) was significantly higher (P=0.01) than the other three treatments in its total yield over the two seasons.

The yields shown in Table VII were obtained from the last three cuts of the experiment after gypsum had been applied to split plots at the rate of 1½ cwt. an acre. Being the total for three cuts only, these figures are lower than those shown in Table VI, which represent the yields of two complete seasons.

TABLE VII—MEAN DRY MATTER YIELD OF LUCERNE AND RUSSIAN COMFREY FOR THREE CUTS FOLLOWING AN APPLICATION OF GYPSUM ON SPLIT PLOTS

(*cwt. per acre*)

Treatments	Lucerne		Comfrey		Mean
	L0	L1	C0	C1	
Control ..	7·67	9·47	9·20	8·00	8·59
Gypsum ..	11·13	14·60	9·93	8·60	14·75
Mean ..	9·40	12·04	9·57	8·30	

Statistical analysis of these results showed that the gypsum produced a highly significant increase in the yield of lucerne ($P = 0.001$) but not in the yield of comfrey.

Summary of Results

Apart from a number of other disadvantages in its use, Russian comfrey has been shown to be inferior to lucerne in the following respects:—

(i) it gives a lower dry-matter yield;

(ii) its percentage of dry matter and crude protein are lower than those of lucerne;

(iii) the digestibility of the crude protein is lower in comfrey than in lucerne;

(iv) soil contamination of the herbage is considerably greater on comfrey than on lucerne.

Russian comfrey was therefore inferior to lucerne under the conditions of this experiment, except in its lower fibre content, which would favour it to some extent for feeding to pigs and poultry. The growth of the lucerne was markedly stimulated by an application of gypsum.

References

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REVIEW

THE GRAFTER'S HANDBOOK, by R. J. Garner, Revised Edition. Published by Faber & Faber Ltd., 24 Russell Square, London, 1958, pp. 260, price 25*s*.

This splendid book, first published in 1947, has been brought up to date by the author. The nine chapters cover every conceivable aspect of grafting and more than fifty different methods of budding and grafting are described in most explicit terms.

Compatibility, the propagation of rootstock, and the collection of scion material are discussed. Being complete master of his subject, the author makes numerous operations clear and easy to follow, with 117 diagrams and 32 plates.

Anyone in East Africa in any way interested in grafting should have this book.

W.B.M.

THE SELECTION OF TROPICAL LEY GRASSES IN KENYA: GENERAL CONSIDERATIONS AND METHODS

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The cultivation of grasses in Kenya is increasing very rapidly as a result of general improvements in farming methods, and there is now a large and increasing demand for good quality strains of ley grasses suitable for various local conditions. For areas of high altitude, with climatic conditions approaching those of temperate European countries, European or American grasses such as cocksfoot, ryegrass, fescue, brome grass and other less important species can satisfy the demand. The selection of strains of these grasses is dealt with at the high-altitude Grassland Research Station at Molo. The selection and strain-building of tropical grasses, suitable for lower altitudes and warmer, and often also drier conditions, is concentrated on the Grassland Research Station at Kitale, which is situated in Western Kenya at 6,200 ft. (1,900 m.) altitude. The rainfall is about 45 in. (1,100 mm.) per annum, falling mostly in one long rainy season lasting from April to September. It is this latter work which is described in this paper.

The conditions of the work of a grass breeder in Kenya differ considerably from those of his counterpart in most of the European continental countries and in the United Kingdom. In Britain and in almost any single country of Western Europe, climatic conditions vary much less than in Kenya, where distinct climates change over relatively short distances from the purely tropical in the coastal belt to the cool and temperate in the highlands. The rainfall varies from about 100 in. per annum on the Nyambeni Range north-east of Mt. Kenya to less than 10 in. per annum in the dry deserts of northern Kenya. Even if the areas of desert and semi-desert are excluded, the variation of climatic conditions in the areas of arable cultivation still remains very high, and a large number of species and strains of cultivated grasses is required to suit these various conditions. These requirements cannot be fully satisfied for a long time to come because the extent of the work done on grass breeding in Kenya is only a fraction of that undertaken in the United Kingdom. Although we may hope for better facilities for grass breeding in Kenya and in other East African territories in the future, it is doubtful if the present agricultural economy of Kenya can afford to finance a grass-breeding programme extensive enough to approach the intensity of similar work in Europe, and satisfy the need for high quality grass strains suitable for various regions of Kenya. The grass breeder in this country cannot afford to use the elaborate methods in current use in Europe, and he must concentrate on the simplest forms of selection and strain-building, though he may apply a more elaborate breeding programme in exceptional cases. His main aim should be the simple selection of grass strains of reasonable quality in as short a time as possible. In any country that is young from the point of view of grass cultivation the first efforts of methodical search for better material nearly always produce quick results, and we in East Africa are fortunate in having a very rich grass flora (Bogdan, 1958a), and a particularly wide range of intraspecific variation in the local grass species suitable for introduction into cultivation. We are also fortunate in having amongst the local and introduced tropical perennial ley grasses about 50 per cent, if not more, of autogamous, usually apomictic species, which breed true to type and do not mix, so that the varieties of these can be used direct as ready-made strains. Simple selection and strain-building in this type of grass is easy, although more elaborate breeding may be more difficult than in the xenogamous species, the type which strongly prevails amongst the European cultivated perennial grasses.

Ley Grasses for Kenya

Until recently, only three of the tropical grass species—Rhodes grass, Molasses grass and Elephant grass—were cultivated in Kenya on a fairly large scale. At present, another grass—a variety of *Setaria sphacelata* from the Nandi district, commonly known in Kenya as "Nandi Setaria"—is entering cultivation and it is rapidly taking its place as an important ley grass. Other species which may be introduced into cultivation in the near future are *Panicum maximum* (Guinea grass), *Cynodon dactylon* and *C. plectostachyus* (Star grass),

Panicum coloratum (Coloured Guinea) and *Cenchrus ciliaris* (African foxtail). Some others, for the time being, are less important, viz.: *Brachiaria ruziziensis, Beckeropsis uniseta, Bothriochloa insculpta,* species of *Paspalum* and others. Most of these species are suitable for cultivation from about 4,000 to 7,000 ft. altitude, and some of them can be grown under a wider range of altitudes: Rhodes grass can be grown below 4,000 ft. altitude while *Setaria sphacelata* may be suitable for cultivation up to 8,000 ft. and probably even higher. There are also grasses such as *Cenchrus ciliaris, Bothriochloa insculpta* and *Eragrostis superba* which are intended for dry, marginal areas, and work on these species is done on a new Agricultural Station near Machakos.

The main bulk of the promising grasses listed above, with the exception of *Paspalum,* belongs to the local East African species. These species occur in East Africa in a great variety of forms, a large number of which show high productivity and good herbage quality. In our variety trials the local types have been almost invariably superior to the introduced varieties. A high degree of variation in several East African pasture and fodder grasses has already been noted by Hartley and Williams (1956). They recognize two centres of polymorphism of the pasture and fodder grasses: the main centre is in the northern Mediterranean where more than 20 cultivated grasses are highly polymorphic, and another centre is in East Africa, with up to ten polymorphic pasture and fodder grass species, either already cultivated or under trial as potential ley grasses. This explains the enormous wealth of material we have in Kenya, and for selection of the outstanding types of tropical ley and fodder grasses we have to rely mainly on our local East African varieties.

Breeding Habits and Strain Building

Until very recently the selection of better types of ley and fodder grasses at Kitale followed, as a rule, a simple and uniform pattern: a large number of varieties or ecotypes of each important grass species, collected in East Africa and also in various other countries, must pass through a preliminary evaluation in the nursery in small observational plots. The better types selected in the nursery are next studied in larger duplicated plots under grazing conditions. Those grasses which continue to show outstanding results pass yet another trial, on a still larger scale, akin to farming conditions. After this the selected varieties are multiplied either for distribution or for trial in other parts of Kenya, under different climatic conditions. At the moment, by retaining the general scheme of evaluation in three stages, attempts are being made to introduce a differential approach to individual species in accordance with their breeding habits. A knowledge of breeding habits for selection and strain building is of primary importance. It is essential to know whether a grass reproduces itself by cross fertilization or is self-fertile. In tropical grasses, at least in the majority of those cultivated in East Africa, only cross-fertilization represents a true sexual reproduction while the self-fertile grasses are usually apomictic; the embryo, and the plant into which it develops, is formed without true sexual process as the male gamete does not take part in the formation of the embryo. In apomictic species the reproduction by seed is actually a vegetative reproduction, and it can be compared with reproduction by stolons, by rhizomes or by a simple division of tufts. Pollination is, however, often needed to stimulate the initiation of the embryo or the formation of the endosperm, as is the case with *Cenchrus ciliaris* and with *Panicum maximum.*

The strains or varieties of purely apomictic species can be compared with clones. They are uniform and they produce uniform and true-to-type progeny. Their response to new environments is also uniform and may be compared with the response of an individual plant. The selection of superior strains or types is straightforward and easy. Actually, the strains are ready-made and they can be easily reproduced in their true form by seed. True breeding, i.e. combining desirable characters or strengthening them by gradual accumulation, is virtually excluded unless the species or variety are not purely apomictic and cross-fertilization occurs occasionally, as in *Panicum maximum.* The apomictic species are often poor seed producers. The poor seed formation can be partially explained by frequent abnormalities which usually accompany apomictic reproduction (Warmke, 1954). No isolation is required for seed production of the purely apomictic grasses except for a few yards to prevent mechanical mixing at harvest time. When collecting wild growing plants for trial, one tuft or a small amount of seed from one or a few plants may be sufficient.

The varieties or strains of the cross-fertilized grasses are usually not uniform and consist of a number of forms which, depending on the variety, differ slightly or very considerably. Their progenies are often not true to type and not uniform. The response to new environments varies with individual plants, and the strain may change in a few generations due to the natural selection of plants more suited to the new conditions. As a rule, the seed production of the cross-fertilized plants is relatively good. Strain-building may be laborious, and inbreeding is often necessary to make the strain more uniform. An ample isolation from other cultivated or wild types of the same species is needed to maintain the purity of the strain. Several roots or tufts representing the population or an adequate sample of seed from several plants are required as initial material for trial.

The mode of reproduction can be determined by: (1) enclosing flowering heads in bags and comparing the formation of seed in the enclosed heads with that of the free-flowering heads; (2) progeny tests; (3) studying the process of fertilization and of embryo-formation, using the microscope; and (4) studying the mechanism of flowering. Neither staff nor equipment is available at Kitale for a microscopic study of the processes of fertilization. Observations on the mechanism of flowering cannot usually produce conclusive results and therefore can be used only to support the findings obtained by other methods. In our studies of breeding habits, which are still in their initial stages, bagging and progeny tests are being used.

The technique of bagging the flowering heads is extensively used, and conclusions concerning the mode of reproduction of the majority of grass species are based on the results of this technique. It is an easy procedure and it gives clear indications as to whether a grass is essentially cross- or self-fertilized or, rather, as to whether the grass can or cannot produce seed without receiving pollen from other flowering heads, particularly from a different plant. In the majority of the grass species, either one or the other type of fertilization prevails strongly, and if the bagged heads produce seed easily, cross-pollination is usually excluded or it occurs only to a very limited extent. However, there is always a possibility that even highly self-fertile plants may cross-fertilize to a certain extent, and so by using the technique of "bagging" one cannot be certain that varieties of the same species that appear to be essentially self-fertilized would not mix and remain pure when reproduced by seed on the same farm. We have tried this technique on a few grass species only, and we intend to use it more extensively in future.

Progeny tests give a practical answer to the question of whether varieties or individual plants of the same species can actually cross if they are grown close together. At Kitale, progenies of *Cenchrus ciliaris* and *Melinis minutiflora*, and to a lesser extent those of *Setaria sphacelata, Chloris gayana*, and *Brachiaria brizantha* and *B. ruziziensis*, have been studied. Seed of a few easily distinguished varieties collected from plants growing in adjacent plots were planted, and the resulting plants studied for uniformity and for trueness to type.

Information on the breeding habits of the tropical grasses, cultivated or intended for cultivation in East Africa, is very incomplete. Gildenhuys (1950) in South Africa studied *Setaria sphacelata* and found that it is predominantly a cross-fertilized species. Snyder, Hernandez and Warmke (1955) in the United States of America studied the breeding behaviour and the development of the seed and of the embryo in *Cenchrus ciliaris* and *Cenchrus setigerus* and found them apomictic. In these two species pollination is, however, needed for the formation of endosperm and to stimulate embryo development. Warmke (1954) found *Panicum maximum* to be a facultatively apomictic species; in the varieties he studied, natural cross-fertilization was observed from 1 to 5 per cent, depending on the variety. Burton (1955) studied the breeding behaviour of Bahia grass (*Paspalum notatum*). His study showed that the Pensacola variety of this grass is essentially a cross-fertilized type while the other types of *Paspalum notatum* are predominantly apomictic. A study of the progeny of *Cynodon dactylon* also by Burton (1947) indicates that it is a cross-fertilizing species. Celarier and Harlan (1957) found *Bothriochloa insculpta* to be an apomict. No information on the mode of reproduction of Rhodes grass and Molasses grass has been found in the literature, and attempts to study the breeding behaviour of these two grasses as well as some other less important species have been made at Kitale. Our preliminary observations support the findings of Snyder *et al.* (1955) that no crossing occurs between

varieties of *Cenchrus ciliaris* and that it always breeds true to type. Molasses grass apparently also belongs to this self-fertile, non-crossing type. *Brachiaria ruziziensis* and *B. brizantha* breed true to type and their flowering heads form seeds well, when enclosed in bags. Rhodes grass forms very little or no seed in enclosed panicles and initial progeny tests suggest that it is a cross-fertilizing plant.

The available information on the breeding behaviour of the tropical grasses used in Kenya or intended for use are summarized in Table I.

It appears that of our important grasses, only *Setaria sphacelata, Chloris gayana* and *Cynodon dactylon* are cross-fertilized plants; the remaining species are self-fertile and they are most probably apomictic: obligatory or facultative. Although Burton (1958) states that apomixis is a commonly occurring method of reproduction in many grasses, nearly all European perennial ley grasses, with the exception of *Poa pratensis* (Fryxell, 1957) are essentially cross-fertilized. The methods and the technique of selection, breeding and strain-building of perennial grasses worked out in Britain and on the continent of Europe are based on the mode of reproduction typical of the cross-fertilized plants. They can be applied in Kenya only to *Setaria sphacelata* and *Cynodon dactylon,* and possibly to *Chloris gayana,* provided that further investigations confirm the results of our preliminary, and consequently incomplete, studies. For *Melinis minutiflora, Panicum maximum, Cenchrus ciliaris,* and *Brachiaria brizantha,* which are either proved or suspected apomicts, the methods of selection and strain building must differ from those used for the European perennial grasses. The factors involved in selection and strain-building of the most important tropical grasses of Kenya, together with some results already obtained, are outlined below, together with some recommendations as to future work.

Setaria Sphacelata

Setaria sphacelata is a valuable ley grass and its importance in Kenya is rapidly increasing. The attractive features of this grass are its persistence, productivity, high palatability and relatively good seed production. These valuable features outweigh its negative characteristics, viz.: its tufted habit and its tendency to go to stem too early. The breeding behaviour and fertility of eight varieties of *Setaria sphacelata* have been investigated in detail by Gildenhuys (1950) in South Africa. Using the bagging technique, he found that *S. sphacelata* is essentially a cross-fertilized species with the average ratio of cross-fertilized to self-fertilized seed being 7.15; or 25 seeds per 100 openly pollinated spikelets as compared with 3.5 seeds per 100 spikelets enclosed in bags. This ratio of cross- to self-pollinated seed varied in individual ecotypes from 2.9 to 60.1 and was the highest in the well-known Kazungulu variety in which self-pollination was practically excluded. Gildenhuys notes that the "indications are that cross-incompatibility exists between two of the ecotypes used for investigation".

At Kitale a large number of samples of *Setaria sphacelata* have been collected in the nursery. These originate mainly from various parts of East Africa, although several samples were obtained from South Africa and the Belgian Congo. The samples were studied in

Table I.—Breeding Behaviour of Kenya Ley Grasses

Species	Type of Reproduction	Authority
Setaria sphacelata ..	Cross fertilization to a high degree ..	Work of Gildenhuys in S. Africa. KGRS ** preliminary progeny tests.
Chloris gayana *.. ..	Probably prevailing of cross-fertilization.	KGRS bagging and preliminary progeny tests.
*Cynodon dactylon** ..	Cross-fertilization	Work of Burton, U.S.A.
Panicum maximum ..	Essentially apomictic with up to 5 per cent of cross-fertilization.	Work of Warmke, U.S.A.
*Melinis minutiflora** ..	Self-fertile (possibly apomictic) ..	KGRS bagging and progeny tests.
Cenchrus ciliaris ..	Obligatory apomictic	Work of Snyder *et al.* KGRS bagging and progeny tests.
Brachiaria brizantha and *B. ruziziensis**.	? Self-fertile probably apomictic ..	KGRS preliminary progeny tests and bagging.
Bothriochloa insculpta ..	Apomictic	Work of Celarier and Harlan, U.S.A.

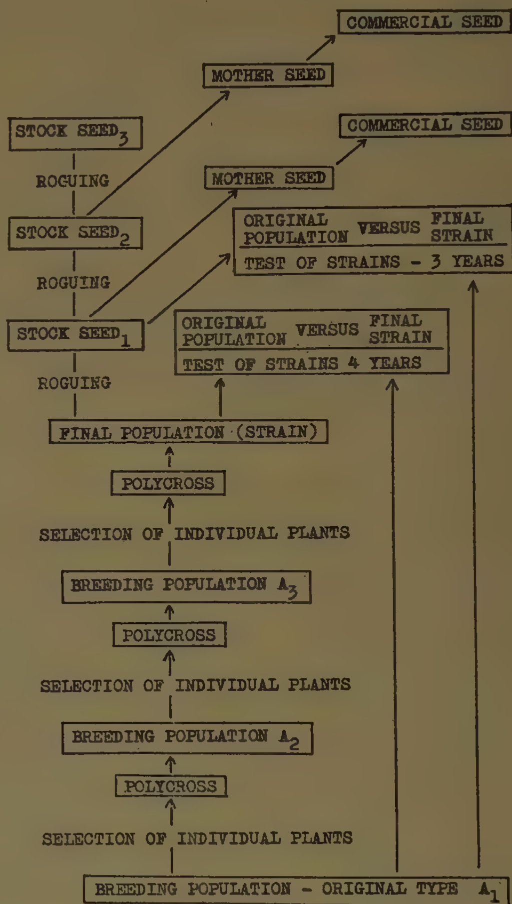
*Little is known; further investigation required. **KGRS—Kitale Grassland Research Station.

small plots under a clipping technique because planting larger plots for trial under grazing was restricted by the necessity of growing seed under isolation. About 12 varieties were found to be of high productivity and good herbage quality. Of these, the most outstanding type was brought by D.C. Edwards from the Nandi district of Kenya. This type, now well-known in Kenya as "Nandi Setaria", is being introduced into cultivation on a large scale and the seed of this grass is bulked on a commercial scale. The Nandi strain of *Setaria sphacelata* is not uniform and represents a highly variable population. A study of this population in 1953 revealed a great number of distinct forms which differed considerably in morphology and also in important characteristics of practical value. The considerable variation inside the strain promised the possibility for improvement, and work on selecting a better type was undertaken. It was hoped that a better strain would be produced in as few generations as possible. Attention was directed to vigour, leafiness and late flowering. Selection for persistence was not included as it would lengthen the process of building of a new strain; moreover, Nandi Setaria, and the species *Setaria sphacelata* generally, persist well, and last easily four years, a long enough period for the ordinary ley. No attempt was made to develop a morphologically uniform type, since this also would require more time and might result in losing some valuable genes. In this respect, by necessity, we follow the American breeders who often produce strains that are not uniform in appearance (William Davies, 1951). The scheme for the improvement of Nandi Setaria, which is given as Fig. I, has been adopted.

Each breeding population consists of about 1,200 plants and, about 40 outstanding plants are selected each time for polycross. At the time of writing, a third selection has just been completed and the selected plants have been planted out for the last polycross. There are indications that our attempts to build an improved strain may be successful.

Another outstanding type only recently obtained is a variety found in the Meru district by V. E. M. Burke. It is being compared with Nandi and Kazungulu varieties under grazing, and so far it has been found outstanding in that it has large, slightly spreading tufts, and vigorous and leafy bright-geen herbage.

Some good types of *Setaria* could be used for building synthetic strains, an important type of strain for a cross-pollinated plant.



In Kenya, wild varieties of *Setaria sphacelata* and also of *Setaria trinervia*, a closely allied species, are common, and in some parts of the country very numerous. As a source of possible contamination these plants may be a nuisance when a pure strain of *Setaria sphacelata* is being cultivated for seed. An investigation has been started at Kitale in order to find out whether these types cross easily with the cultivated *Setaria*. This work is still in its infancy, but the indications are that the danger of crossing may not be great.

In certain areas of Kenya *Setaria sphacelata* is severely attacked by bunt (caused by *Tilletia echinosperma*). It seems that all varieties are susceptible to bunt, and it is hardly possible that resistant strains can be developed.

CHLORIS GAYANA, RHODES GRASS

No information on the mode of reproduction of Rhodes grass has been found in literature. Judging by our very preliminary bagging tests (Bogdan, 1958b) and by progeny tests, this grass seems to be essentially a cross-fertilized, xenogamous species; this, however, has yet to be confirmed by more detailed investigations. At present, we regard Rhodes grass provisionally as a xenogamous plant and plan our strain building programme accordingly; we also take necessary precautions to prevent the existing type from mixing by isolating pure varieties when grown for seed. The natural populations of Rhodes grass look fairly uniform, more uniform than, say, those of *Setaria sphacelata.* Their uniformity may, however, be deceptive, as it is almost impossible to distinguish individual plants in a sward of this stoloniferous grass, and, indeed, the first uniformity tests show that varieties of Rhodes grass are not uniform. Of the few varieties which passed the uniformity test at Kitale not one has yet shown complete uniformity such as is observed in strains of Molasses grass or *Cenchrus ciliaris.* Some varieties, e.g. Mpwapwa, are, however, less uniform than others, e.g. Mbarara. There is great scope for improving the existing strains, for uniformity tests show that a population usually contains valuable outstanding plants, together, of course, with inferior ones which as a rule are more numerous.

As a result of observations made in the nursery and in large-scale trials, about ten promising varieties have been selected out of more than 50 original samples grown at Kitale. These outstanding types are now being compared on a large scale, not only at Kitale but also outside the Trans Nzoia district, several sets of the best varieties having been sent to agricultural stations in other parts of Kenya for trial. As in the other ley grasses the varieties are selected for vigour, leafiness, leaf quality, seed-setting and persistence. In Rhodes grass, persistence is of particular importance, for this grass does not often persist for more than three years; it may not even persist for two years. In the majority of varieties, seed-setting is normally satisfactory, but in some varieties seed formation is very poor, possibly because these varieties may have originated from one or very few roots brought to the nursery and multiplied, in fact, as a clone or as a few closely related clones. If a particularly good type shows poor seed formation, as is the case with the Chepararia variety, attempts should be made to find a similar type of different origin, in order to produce a synthetic variety in which seed formation may become better.

At present, seed of only one type—Rongai Rhodes—is easily obtainable on the market. This type of Rhodes grass is well known in Kenya and it is very common in the Rongai area near Nakuru. Rongai Rhodes is very hardy, drought-resistant, and it has satisfactory seeding qualities. On the other hand, it lacks productivity and its nutritive value is not high. Rongai Rhodes grass is not confined to the Rongai area by any means, and it can be found in many parts of Kenya and in East Africa generally; it is actually a group of similar varieties of approximately the same value, though these varieties are not necessarily closely related.

Attempts to introduce into cultivation selected varieties of better quality than the Rongai type have been made since about 1933 when an "Australian" variety from Queensland was reintroduced to Africa (Edwards, 1955). Later two more varieties—"Nzoia" and "Kabete"—were tried (Edwards, 1943) and still later "Alego" variety from the Nyanza Province (Kenya) was included in Edwards' trials. Since that time varieties better than Alego, Kabete and the Australian have been found; the Nzoia variety, however, is still valued as an outstanding type. This latter variety belongs to a very leafy type; the leaves are broad and of good quality, and the seed setting capacity of Nzoia Rhodes is also good. This variety is less stoloniferous than the majority of other types and as a rule it is less persistent, particularly in the areas of poor soil or low rainfall. In some areas, e.g. the Trans Nzoia District, Nzoia Rhodes shows a relatively low resistance to a *Helminthosporium* disease which attacks its leaves. This disease may be the cause of the poor persistence of this variety. In uniformity trials with Nzoia Rhodes some individual plants seem to be resistant to *Helminthosporium.* This is an encouraging fact which indicates the possibility of developing a more persistent variety of the Nzoia type.

Other outstanding varieties which have passed the early stages of evaluation are:—

(i) The *Endebess* variety, which originates from the Endebess area of the Trans Nzoia District. This is an all-round

good type, and in the last few years it has also shown good results in relatively dry areas.

(ii) The *Chepararia* variety from Chepararia in the West Suk District. This is a leafy type of very good herbage quality. Its seed formation is poorer than in the majority of other types under trial, possibly because of its clonal origin.

(iii) The *Mbarara* variety from Uganda. For persistence, this is an outstanding type; in a trial at Kitale it was the most persistent of the 22 varieties under trial. It is a fairly vigorous type and a good seeder. The quality of the herbage, however, is relatively low, particularly in the first and second year of growth, when this variety develops very numerous thin stems. The quality of the herbage usually improves with age, and it becomes fairly good in the third and fourth year.

(iv) The *Mpwapwa* variety, originally obtained from Iringa in Tanganyika, has been cultivated experimentally by H. J. Van Rensburg, at the Mpwapwa Veterinary Research Centre (Tanganyika), with good results. It is a large variety with thick stems and broad leaves. In Kenya it has shown satisfactory results in dry and warm areas.

Amongst the samples collected at Kitale there are also several varieties from outside East Africa; some of these have shown satisfactory results, such as the Katambara variety from Southern Rhodesia, but none is really outstanding.

So far work on the improvement of Rhodes grass has been confined to the selection of better existing types. Since our uniformity tests have shown the great variation of single plants in a seemingly uniform variety, the possibility of improving the existing strains, either by positive methods, i.e. repeated group selection or by roguing, should be carefully examined. Outstanding clones can also be used direct for the small African holdings in the Central Province of Kenya, where Rhodes grass is planted from splits.

Cynodon Dactylon, Common Star Grass

The name *Cynodon dactylon* is used here provisionally; a world-wide revision of the genus *Cynodon* is required before the correct name for the Kenya Common Star grass can be established with accuracy. All varieties of *Cynodon dactylon* which occur naturally in Kenya are stoloniferous (not rhizomatous) and they can, therefore, be used not only for permanent pastures but also for leys without the danger of introducing a noxious weed into arable land. *Cynodon dactylon* can be easily established from splits, and, indeed, farmers in the United States plant Star grass (Bermuda grass) as a rule from splits (Burton, 1956). In Kenya, Star grass would be much more widely used if viable seed could be produced on a commercial scale. The reason for poor seed formation in *Cynodon dactylon* is not yet clear. Most of our varieties produce flowering heads, but these are either insufficient in quantity or the caryopses are not formed, or are formed only sparsely. Our observations indicate that the majority of Kenya varieties can produce seed under certain conditions. For instance, in our preliminary grazing trial of 1956, almost all of the ten varieties of *Cynodon dactylon* produced seed in the year of establishment after having been grazed heavily; the plots yielded up to 40-50 lb. of seed per acre, mostly of good quality with a large proportion of caryopses. In other years, under rather similar conditions, the plants flowered scarcely, or if they flowered well the proportion of caryopses in the seed was negligible. It seems that the formation of viable seed is more a question of suitable conditions than variety. If our East African *Cynodon dactylon* is a cross-fertilized species —(*see* below)—then the low proportion of viable seed can be explained, in many cases, by the fact that the cultivated Star grass is often grown as a clone which, in cross-fertilized plants, is expected to be a poor seeder. A comparison of seed formation in pure clones and in their mixtures is therefore desirable. Often, even if the caryopses are formed, they do not always germinate, and this further complicates the question of Star grass seed production.

The breeding habits of *Cynodon dactylon* have been studied by Burton (1956) in the United States. Using "progeny tests" technique, he came to the conclusion that "*Cynodon dactylon* is a highly cross-pollinated species". Burton also states that "All controlled crosses that have been made have exhibited characteristics of both parents in the F_1. There has been no evidence in the breeding behaviour of Bermuda grass to suggest that it reproduces

itself by apomixis". At Kitale, and on a few farms where Star grass (Bermuda grass of the U.S.A.) is cultivated, it is propagated vegetatively from splits, and therefore the mode of reproduction has not been of much importance. If, in future, Star grass is grown from seed, its breeding behaviour will require to be investigated in Kenya, for Burton's conclusions about the American cultivated types of *Cynodon dactylon* do not necessarily have to agree with the breeding behaviour of our stoloniferous types of *Cynodon*, which may even belong to a different species.

East African varieties of *Cynodon dactylon* belong usually to three fairly distinct types (Bogdan, 1955):—

(1) A large robust type which occurs mostly at forest edges. It is particularly common in Western Kenya (Nyanza Province) and in Uganda; this type is often wrongly referred to as *Cynodon plectostachyus* (Bogdan, 1949).

(2) A fine type with numerous thin and wiry stems and numerous small and short leaves; this type occurs regularly in arid parts of Kenya, usually under waterlogged conditions, often on saline and alkaline soil.

(3) This third type, widely distributed in Kenya, is of medium vigour; it is very ununiform, and includes numerous varieties, many of which produce high-quality herbage. The selection of better types of Star grass should be based essentially on this type.

Numerous clones of *Cynodon dactylon* have been compared at Kitale and the few which gave the best results under grazing belong to the third group. The main work on selection and strain building in Star grass should preferably be done in districts where the soil is fertile; on the relatively poor Kitale soil Star grass varieties do not appear to attain the vigour that they display normally on more fertile soil.

Cynodon Plectostachyus, Naivasha Star Grass

This species is of importance in certain semi-arid parts of Kenya, especially on volcanic ash soils around Lakes Naivasha, Elmenteita and Nakuru. *C. plectostachyus* is a well-defined species and it seems to be much less variable than *C. dactylon*. Samples of *C. plectostachyus* brought from various parts of East Africa were found to be morphologically fairly uniform, although they differed in vigour, leafiness, persistence and susceptibility to disease. Naivasha Star grass is a better seeder than *C. dactylon;* it does not, however, produce seed in areas of high rainfall, including Kitale, as the flowering heads invariably become diseased. Strain building of *C. plectostachyus* should be done, preferably, in the Naivasha-Nakuru area. Nothing is yet known about the breeding habits of this species.

Panicum Maximum, Guinea Grass

Panicum maximum occurs naturally in tropical and southern Africa and it is now widely cultivated in many other tropical and sub-tropical countries (Motta, 1953). There are a few recognized varieties of *Panicum maximum* in central and southern Africa and more in the South American countries, in the West Indies and in Australia; all of them having originated in Africa. *Panicum maximum* varies considerably in all practically important characters; there is, however, only one type which is botanically distinct, it is the var. *trichoglume,* or Slender Guinea. It differs from the rest in having hairy spikelets. It also has a distinct habit of having its leaves placed rather high on the stem while in the other types of *Panicum* these are usually concentrated close to the tuft bases. According to Motta (1953), "White, 1958, separated the types of *Panicum maximum* found growing in Queensland (Australia) into three botanical types: Common Guinea (*Panicum maximum* var. *typica*); Slender Guinea (*P. maximum* var. *trichoglume*); Purple-topped Guinea (*P. maximum* var. *coloratum*)". The latter has no relation to *Panicum coloratum* L. or Coloured Guinea. Slender Guinea is being introduced into cultivation in Kenya more quickly and on a larger scale than the ordinary large and robust types, partly because Slender Guinea has the habit and size of ordinary ley grasses and partly because it produces more seed of slightly better quality than the other types. Nevertheless even Slender Guinea produces seed with a low proportion of the true seed containing caryopses. A commercial supply of seed of Slender Guinea is developing quickly, but it is still in its initial stages.

Many types of Common Guinea, most of them large and robust, have been tried at Kitale and a few of the most productive and leafy ones have been selected for further study. At present Sigor Hairless Guinea (from Sigor

in West Suk, Kenya) and Mackinnon Road Guinea (from Mackinnon Road Railway Station, Kenya) seem to be outstanding. "Sigor Hairless" is suited to medium altitudes while "Mackinnon Road" Guinea can be used in warmer areas at lower altitudes. Some very promising types from the Belgian Congo and Senegal are also being tried. Small forms of the Common Guinea occur in East Africa and a very promising variety of this kind which was found in the Wakamba area is now under trial at Machakos.

Warmke (1954) in Puerto Rico studied the breeding behaviour of *Panicum maximum* and found this species to be a facultative apomict with a certain degree of cross-fertilization which, in the types he studied, varied from 1 to 5 per cent. His findings are based on cytological investigations and on the study of progeny. Warmke states that "The plants in the progeny tests were so uniform in general appearance, growth rate, time of flowering, etc., as to indicate very strongly that they were apomictic". There were also exceptional plants in the progenies and these "differed distinctly from the others in size, vigour, leaf shape, colour, disease susceptibility, etc. The number of exceptional plants was small in all cases—from slightly over one per cent . . . to just less than 5 per cent. . . ." No progeny tests have been undertaken at Kitale, but observations indicate that our varieties of *Panicum maximum* may be apomictic to a still larger degree than those studied by Warmke. However, until we learn more about the breeding behaviour of our East African varieties these are grown for seed production in isolation in order to be on the safe side. By cutting off the stigmas at various times after the anthesis, Warmke found that pollination is needed for seed formation, but not for the formation of the embryo.

Warmke also found that the average set of viable seed was low (4.5 to 48 per cent). He explains this partly by abnormalities in the ovule, which often occur in the apomictic species: "degeneration of all four reduced megaspores, without apospory" and "occurence of more than one embryo sac within an individual ovule". Our varieties under Kitale conditions produce a much lower proportion of viable seed which only occasionally reaches 10 per cent in the Slender Guinea and is usually less than 2 per cent in the Common Guinea. These figures are, however, difficult to compare with those obtained by Warmke. We calculate the proportion of viable seed in a sample of seed harvested on a field scale, where a large proportion of viable seed can either be dropped before the harvest, or be eaten by birds, or be lost during the harvesting, while Warmke probably took all seed into account. His figures should be higher, because well-filled seed containing caryopses fall easily to the ground or are eaten by birds.

As *Panicum maximum* varieties are multiplied by apomictic ("vegetative" seed), it is difficult to suppose that the proportion of viable seed may increase by repeated selection. For better seed production new strains have to be looked for, or the exceptional plants—a result of cross or sexual reproduction—should be examined for better seed setting.

The work with *Panicum maximum* should, I believe, include:—

(i) A continuation of the search for better existing local and introduced varieties with special attention being given to their seeding qualities. The recognized varieties from the main countries growing *Panicum maximum* should be tried in the first instance.

(ii) A study of the progeny of a few distinct varieties grown close together in order to assess the proportion of hybrid plants.

(iii) Attempts to produce the plants from sexual seed and to find amongst them those with better seeding qualities as compared with the parent plants. These better qualities can be fixed by the further apomictic reproduction, a normal type of reproduction in *Panicum maximum*.

Melinis Minutiflora, Molasses Grass

According to "The Flora of West Tropical Africa" (Hutchinson and Dalziel, 1956) *Melinis minutiflora* occurs naturally in Tropical Africa, Mascarene Islands and in Brazil. At Kitale numerous samples have been collected from Kenya and several other countries and grown for comparison. The cultivated forms of this collection are fairly uniform and samples from the Belgian Congo, Nyasaland, Sierra Leone, U.S.A., Uruguay and Venezuela have the same habit and other characteristics and they are almost identical with the Kitale commercial type. The cultivated type is characterized by a very dense form of growth and under grazing the plants form very dense cushions with numerous short leaves. The spikelets are hairless and have long awns. The relative uniformity of the cultivated Molasses grass, which has

now been introduced to various countries far beyond its natural area of distribution, suggests that all cultivated forms may have the same origin, and they probably came from central or southern Africa. Unlike the cultivated material, the local indigenous forms collected from various parts of Kenya show a considerable variation in characteristics of practical importance such as their form of growth, leafiness, seed setting capacity, etc. There are types which under grazing form dense cushions; types with broad, more spreading cushions; upright types with longer, erect leaves; and even a creeping type has been observed. In the panicles and spikelets, however, all samples seem to be uniform except that in a few samples the spikelets are awnless or have very short awns. The degree of development of the glandular hairs on leaves, a characteristic feature of *Melinis minutiflora* also varies and in one sample there were no glands at all, although in all other characteristics this sample was a typical *M. minutiflora*.

A number of samples of Molasses grass which originated from Kenya belong to closely-allied species and have been identified as *M. maitlandii* or *M. tenuinervis* (Napper, 1958). As these species differ from *M. minutiflora* almost entirely by the presence and the character of hairs on spikelets, I am inclined to consider these species only as varieties of *Melinis minutiflora.*

No information on the breeding habits of Molasses grass has been found in literature. In my progeny tests four types were grown close together, and with only one exception three generations of these types produced remarkably uniform and true-to-type progenies. In these tests two varieties of *Melinis minutiflora*, one variety of *M. maitlandii* and one *M. tenuinervis* were tried. It is planned to repeat the progeny tests with a few more varieties of true M. *minutiflora*. Bagging of a few flowering heads has shown that strange pollen is not needed for the seed formation; the control panicles produced only about 50 per cent more seed than the panicles enclosed in bags; this difference can be explained by abnormal conditions for flowering and seed setting in the bags. For more convincing results, however, many more panicles should be bagged. It can be accepted for the time being that Molasses grass is essentially a self-fertile plant and it is most probably an apomictic species, since this type of reproduction is common in the *Paniceæ* tribe to which Molasses grass belongs. The selection and strain building in Molasses grass has therefore to be of the same pattern as that used for self-pollinated and apomictic species. The main attention should be given to simple comparisons of the existing types and to the selection of those superior to the existing commercial variety. These best types can then be regarded as pure strains and they can be immediately introduced into cultivation. There is no need to isolate the seed production plots; it is safer, however, to place these plots several yards apart to prevent mechanical mixing during harvesting, since the light seeds of Molasses grass can be easily blown by wind to adjacent plots. As Molasses grass is cultivated mainly in the Trans Nzoia district, the main work of strain comparison can be done at Kitale where the climatic and soil conditions are most suitable for this species.

The existing commercial type has been compared under grazing with several other outstanding varieties and found to be a sound type which gives good establishment, productivity, persistence and seed-setting. However, under grazing this commercial variety tends to form dense tufts of isolated cushions which do not spread sufficiently. This kind of growth is not ideal in pasture, and so the search for varieties which will form a more uniform sward should continue. We have one promising variety at present, the Chania River variety, found by D. C. Edwards. This forms a much more even sward by producing looser and wider cushions. It is, unfortunately, a relatively poor seeder and is slow to establish. Another promising variety, found on Mboni Hills near Machakos, has a spreading, almost creeping habit, and its seeding qualities are good. This variety has only recently been found and it has yet to be compared with other types under grazing conditions.

Cenchrus Ciliaris (Pennisetum Ciliare), African Foxtail

This grass is highly valued in dry warm countries because of its drought resistance and the good quality of its herbage. It has been introduced into cultivation in several tropical countries and its importance is rapidly increasing. Strains of *Cenchrus ciliaris* have been selected in Australia, in South Africa and in Rhodesia, and work on the selection of local strains is in progress in Kenya and Tanganyika.

Cenchrus ciliaris is a strongly protogynous grass, i.e. with the stigmas exserted 3-4 days

before the anthers appear. The protogyny suggests cross-fertilization or at least geitogamy. However, numerous distinct types of *Cenchrus ciliaris* do not mix and maintain their characteristics in progenies even when grown from seed collected from the varieties grown in adjacent plots. Snyder, Hernandez and Warmke (1955) studied several varieties of *Cenchrus ciliaris* (*Pennisetum ciliare*) and they found this species to be strictly apomictic. Our studies of the progenies of East African varieties have also shown clearly that varieties of *Cenchrus ciliaris* do not mix at all and have a remarkable intrastrain uniformity. Synder *et al.* (*loc. cit.*) found that pollination is required for the formation of seed; this is needed, however, only for the formation of the endosperm and for stimulation of the development of the embryo, but not for the process of fertilization itself.

The natural varieties of *Cenchrus ciliaris* can be regarded as the ready-made strains which in the following generations retain their characters, including the agriculturally important ones, e.g. seed-setting capacity. To obtain an outstanding strain one has merely to compare the existing strains, indigenous and exotic, under grazing, or for seed production, and multiply the seed. Although the possibility of finding natural crosses is not excluded, this can be expected to be only a rare exception, and the strain-building programme for the near future should be based on selection from existing forms. As a long-term policy in strain-building a search for the natural crosses, and the use of colchicine and other stimulants to change the nature of the grass or to increase the ability to cross, must not be overlooked. It has to be kept in mind that characteristics of the strain may be expressed differently under different environments. For example, a common coastal type of *Cenchrus ciliaris* which occurs near Mombasa acquired an entirely different habit when brought to Kitale, retaining, however, its intrastrain uniformity. Therefore, it is necessary that the comparison and evaluation of types should be done in the areas suitable for cultivation of *Cenchrus ciliaris*.

A good strain of *Cenchrus ciliaris* suitable for cultivation in leys should be productive and vigorous; it should have spreading or semi-spreading shaped tufts under grazing conditions, and it should possess good quality herbage. It should also produce viable seed in sufficient quantity for commercial seed production. A number of natural strains have the tufts too tough and too strong to be easily ploughed, and this quality should also be taken into account. In an evaluation of strains persistence is not of particular importance, since nearly all our strains persist long enough for the duration of the grass break in the rotation, which usually does not exceed four years. Only two exceptions to this have been obtained at Kitale. No isolation is required for seed plots of different strains.

The samples collected at Kitale belong to very numerous types which are not easy to classify. There is, however, one distinct group of varieties; it is a rhizomatous type which develops short and stout rhizomes from one to a few per plant, while all other types have no rhizomes. This rhizomatous type always has bluish leaves and very strong, wiry stems. We regard this type as inferior and unsuitable for cultivation. Of the promising types which have shown good results at Kitale the following are worth mentioning:—

K5148 brought in by D. C. Edwards and selected at Kabete. This is a tall, erect type, productive but more suitable for hay than for grazing. It has a good seed-setting capacity and the seeds germinate freely.

K5146 is also a Kabete selection; it is a low, dense type suitable for grazing and it gives a good quality herbage. Seed production is poor.

K51313 from West Suk (Kenya) represents a very good leafy, erect form. The production of viable seed is rather low.

K53775 from the semi-arid parts of Meru District (Kenya). It has a semi-prostrate form of growth; the herbage is dense and of good quality. Seed production is good but the proportion of viable seed it not high.

Of the recognized exotic varieties, the Biluela and Chipinga strains have been tried. The Chipinga strain belongs to the bluish, rhizomatous type; under our conditions both strains have been found to be of relatively low herbage quality though they are hardy and productive.

The selection of strains of Cenchrus is now based on Machakos, a semi-arid area more suitable for *Cenchrus ciliaris* than Kitale. A few valuable forms have already been selected there.

Another species of *Cenchrus*—*C. setigerus*—has the advantage of having spikelets without bristles. The seed therefore is not fluffy; this

is a considerable advantage over *C. ciliaris*. In habit and leafiness *Cenchrus setigerus* resembles a good type of *C. ciliaris* but there are reports that it is less productive under grazing. Snyder *et al.* (*loc. cit.*) found this species to be apomictic. Although the present variety seems to be less valuable than the best strains of *C. ciliaris*, the possibility of finding a good, productive type is not excluded. All our samples of *C. setigerus* produce an ample amount of seed with a high proportion of caryopses; the rate of germination, however, is invariably low.

Brachiaria Brizantha and B. Ruziziensis, Signal Grass

Germain and Evrard (1953) have recently described a new species—*B. ruziziensis*. Until then, this grass was regarded at Kitale only as a variety of *B. brizantha*. *B. ruziziensis* has a prostrate or semi-prostrate form of growth, produces good quality herbage, and as a pasture plant it is generally superior to *B. brizantha*, which has more erect habit and harder leaves. Several types of both *B. brizantha* and *B. ruziziensis* were under trial at Kitale for some years, but their introduction into cultivation was not possible because of the poor seeding quality of both species. At present there are better prospects for cultivation of *B. ruziziensis* as the varieties which have been recently introduced from the Belgian Congo seem to be better seed producers.

Nothing could be found in the literature on the breeding behaviour of *Brachiaria*. Observations made by Strange at Kitale and small scale bagging suggest apomictic reproduction.

Bothriochloa Insculpta, Sweet Pitted Grass

This grass has shown good promise for cultivation on black, heavy, waterlogged soils in the semi-arid areas of Kenya. A few local varieties of *B. insculpta* are under trial at Machakos and seed of one variety is being bulked rapidly. No isolation is required when different varieties are grown for seed as Celarier and Harlan (1957) have recently found that *Bothriochloa insculpta* is a strictly apomictic species.

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Addendum

Since this article was submitted for publication I have obtained a copy of "Some South African Apomictic Grasses", by W. V. Brown and W. H. P. Emery, published in the Journal of South African Botany, Vol. XXIII, 1957. The authors state that *Brachiaria brizantha* is an apomictic species, thus supporting our views on the breeding behaviour of this grass. According to Brown and Emery *Chloris gayana* is an apomict; this, however, refers only to the tetraploid forms and they suggest that diploid plants of this species are probably sexual.

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REVIEWS

INDUSTRIAL FIBRES, 1958: A review of production, trade, etc., relating to cotton, wool, rayon and other man-made fibres, mohair, silk, flax, jute and jute manufactures, sisal and other hemps, coir and kapok; 212 pages, price 5*s.* net (5*s.* 9*d.* per copy post free). Obtainable from H.M. Stationery Office, or from the Secretary, Commonwealth Economic Committee, 2, Queen Anne's Gate Buildings, Dartmouth Street, London, S.W.1.

World production of the chief industrial fibres rose for the third successive season in 1956-57 to a new record level. The increase applied to all the main fibres except cotton. Aggregate fibre production in the free world during 1956-57 was very slightly higher than in the previous season, and the estimated total of 28,300,000,000 lb. was the largest ever recorded. Total fibre production in the Commonwealth continued to rise, appreciable increases in wool, cotton, sisal, man-made fibres and jute being recorded compared with the previous season, although flax output continued to fall.

World consumption of the main apparel fibres again increased during the period under review, the overall rise amounting to some 4 per cent. Stocks, by contrast, showed a downward trend. Those of cotton fell for the first time since 1950-51, as a result of the sustained level of consumer demand and of the measures taken by the United States Government to dispose of its surplus holdings. Stocks of wool and jute also declined between 1956 and 1957.

Price trends of the different industrial fibres exhibited quite marked divergencies during the 1956-57 season, but on balance world prices of cotton, silk, flax and sisal were lower than in the previous season, while those of wool, jute and manila hemp were noticeably higher. In the closing months of 1957, however, the movement towards a lower basis of prices became more widespread.

PRODUCTION

Total fibre production in the free world in 1956-57 was a shade higher than in the previous season. The overall output of natural fibres showed a slight decline but those of man-made fibres rose by 5 per cent, which caused their share of aggregate output to increase from 17 to 18 per cent. The Commonwealth produced a larger proportion of the world output of cotton, wool and the newer man-made fibres than in the previous season. Commonwealth production of rayon and hard hemp also registered an increase, but its proportion of the world total was somewhat lower, since output in the rest of the world expanded even more rapidly.

The review summarizes developments in cotton production during 1956-57, when the total crop in the non-Communist world was 3 per cent lower than in the previous season, chiefly accounted for by a reduction in the United States, where acreage restrictions brought about a 5 per cent cut in output. Wool production, on a clean basis, was 6 per cent greater than in 1955-56, while there was an increase of 5 per cent in the output of

TOTAL PRODUCTION OF INDUSTRIAL FIBRES IN THE FREE WORLD
(*thousand million lb.*)

	Pre-war average	1952–53	1953–54	1954–55	1955–56	1956–57
Cotton	11·6	13·9	14·5	14·2	14·7	14·3
Wool (clean basis)	1·8	2·2	2·2	2·2	2·3	2·4
Rayon and Acetate:						
Filament yarn	1·0	1·7	1·9	1·9	2·1	2·0
Staple fibre	0·4	1·4	1·7	2·0	2·2	2·5
Nylon and other man-made fibres	—	0·3	0·3	0·4	0·6	0·7
Silk	0·1	*	*	*	*	*
Flax	0·2	0·3	0·2	0·3	0·3	0·3
Hemp (including sisal)	1·9	1·9	2·0	2·0	2·0	2·1
Jute	3·3	4·7	2·8	3·1	4·0	4·0
TOTAL	20·3	26·3	25·7	26·1	28·3	28·3
Man-made fibres as per cent of total ..	6·7	12·6	15·3	16·4	17·2	18·0

*Less than 50 million lb.

man-made fibres (including a rise of 16 per cent in that of nylon and the newer non-cellulosic types). Production of non-apparel fibres rose by about 2 per cent over the previous season's total, primarily as a result of a 5 per cent increase in sisal and other hemps, since the world jute crop was virtually unchanged compared with 1955-56.

During the second half of 1956 and the first half of 1957, prices of cotton, silk, flax and sisal were, on balance, lower than a year earlier, but those of wool, jute and manila hemp were all higher. Rayon yarn prices in the United Kingdom were raised by about 10 per cent in January, 1957—the first general increase for several years. Cotton prices tended downwards until March, 1957, following the first disposals programme of United States surplus stocks for export at competitive prices, but throughout the remainder of the year they held firm on their new, lower basis. The upward trend in wool prices continued until May, 1957, but a decline then set in and in the first half of the 1957-58 season, values were on a substantially lower basis. The downward trend in flax quotations, which continued throughout 1957, was chiefly the result of heavy sales of Russian flax at competitive prices. As a result of the Suez crisis, prices of both jute and sisal had risen at the end of 1956, but from February, 1957, until the end of the year the trend was downward.

Trade

The Commonwealth is an important supplier of industrial fibres to the rest of the world. Almost all the world's jute entering international trade is of Commonwealth origin, together with over three-quarters of the wool, nearly two-fifths of the hemp, a sixth of the cotton and a tenth of the man-made fibres. Overall, the Commonwealth has a substantial export balance in fibres, since its net exports of wool, jute and hemp outweigh its net imports of cotton, flax, rayon and silk. The export balance in wool rose steadily from just over 1,000,000,000 lb. in 1953 to 1,275,000,000 lb. three years later, and net exports of hemp in 1956 at 100,000 tons were half as great again as in the previous year and the highest since 1949. Net exports of jute were again very high at 528,000 tons, and only 2 per cent short of the previous year's record. Net imports of cotton rose sharply in 1956 to nearly 600,000,000 lb. following increased Commonwealth purchases of American growths, while the import balance in man-made fibres also rose sharply to 114,000,000 lb. or over twice as much as in the previous year, due mainly to a doubling of Indian imports and a fall in United Kingdom exports.

Commonwealth countries provide a substantial proportion of the United Kingdom's imports of the chief industrial fibres. Between 80 and 90 per cent of this country's wool supplies are normally drawn from the Commonwealth and about one-fifth of its cotton, in each case a rather higher proportion than before the war. All the United Kingdom's jute and coir come from Commonwealth sources as well as about 80 per cent of its hemp, compared with only 40 per cent before the war.

A special section in the review describes changes in the position of the Six Common Market countries of Western Europe as markets for Commonwealth fibres. Nearly the whole of Western Europe's supplies of raw

United Kingdom Price Indices for Selected Industrial Fibres

1947 = 100 (except flax: 1948 = 100)

Calendar year	Cotton (American)	Wool	Silk	Flax	Sisal	Jute
1934–38 average	31	48	32	37	28	21
1952	192	228	151	140	211	126
1953	155	261	160	116	124	98
1954	161	250	146	116	113	107
1955	155	225	136	113	107	102
1956	132	228	128	103	103	104
1957	124	257	126	98	95	120
December, 1956	128	254	129	107	99	127
December, 1957	125	213	122	93	92	111

jute normally come from Commonwealth sources, together with over 80 per cent of its wool imports and nearly 40 per cent of its hemp. Western Europe's imports of Commonwealth wool have increased both absolutely and relatively in recent years and there has also been a marked rise in imports of Commonwealth hemp (sisal). By contrast, fairly small quantities of Commonwealth cotton are imported, and "the Six" are themselves substantial producers of man-made fibres and also of jute manufactures, which are both protected by relatively high import duties.

New Fibres

At the present time many of the most significant developments in the whole textile field are those affecting the newer, non-cellulosic man-made fibres. Production of the newer fibres continues to increase rapidly; in 1956 (the latest year for which full figures are available), there was a 16 per cent rise in world output to about 650,000 lb. although the rate of increase was somewhat less than in the previous year. The United States remained the largest single producer, followed by Japan, which has now replaced the United Kingdom as the second largest manufacturer. Nylon still accounts for the bulk of the total, but its proportion has declined with the development of the newer polyester and acrylic fibres such as Terylene, Orlon and Acrilan. The capacity of the industry is being further expanded in all major producing countries and by the end of 1958 it is expected to be at least 1,400,000,000 lb. or twice as great as in 1956.

Tea, by T. Eden, published by Longmans, Green and Company, London, 1958, pp. 201, price *35s.*

This is the third to be published of a series of books on tropical agriculture which Longmans, Green and Company are bringing out with the active encouragement of the Colonial Advisory Council on Agriculture, Animal Health and Forestry. The author, Dr. T. Eden, needs no introduction to readers in Ceylon and East Africa; his earlier publications on tea will be familiar, notably the Monograph published in 1949 on the work of the Agricultural Chemistry Department of the Tea Research Institute of Ceylon.

The present book, like that Monograph, is soundly based on fundamental agricultural and technological principles, and the author has set out to give an account of tea cultivation and manufacture in relation to those principles. It is not, and is not intended to be, a planting manual. Nevertheless there are few practical problems in the solution of which some assistance cannot be found, the details being perhaps filled in by the advice of local research stations.

Examples could be multiplied, but the reviewer would select that of the vexed question of "skiffing" (page 55). The author discusses the pros and cons, and concludes that skiffing in the hope of extending the pruning cycle is "a risky procedure not calculated to benefit the bush as a whole". "The bush as a whole" is indeed an epitome of Dr. Eden's philosophy of tea growing. Chapter VI, "Pruning and Plucking" (in which the quoted section on skiffing occurs), should be carefully studied, with its insistence on balance of growth, since this is a subject upon which even experienced planters hold misconceptions.

Of all tea cultivation matters, that of shade is perhaps the most contentious, which is a clear indication that much more research work is required. The author (Chapter IX) gives a judicious account of the present position. Recent observations following a most severe drought in Nyasaland and Portuguese East Africa support Dr. Eden's view that the presence of shade in the disseminated form that is usual on tea estates lowers the temperature of the ambient air and reduces transpiration. Certainly tea under shade survived the drought much better than unshaded tea.

In Chapters X and XI on diseases and pests, no attempt has been made to be encylopaedic, but all the more important are described and control measures discussed. It is a pleasure to note the author's care to ensure up-to-date accuracy in the botanical and zoological nomenclature.

Research on the chemistry of tea leaf and its fermentation has made great strides since the war, and in Chapter XII Dr. Eden gives an account of the position at 1955. The study of the chemistry of fermentation has progressed since then, but the over-all picture has not greatly changed. Chapter XIII has a general account of orthodox manufacture, followed by a section on non-wither teas and other modifications in manufacturing methods.

The final Chapters XIV and XV give a review of the Tea Trade and Industry, including a short account of each of the principal research stations—Proefstation voor Thee

(Indonesia, founded 1893); Indian Tea Association Scientific Dept. (Tocklai Experimental Station, 1900); Tea Research Institute, Ceylon (1925); United Planters' Association of S. India, Devarshola Tea Experiment Station (1926); Tea Research Institute of East Africa (1951); Department of Agriculture, Nyasaland, Tea Research Station, Mimosa, Mlange.

Reference must be made to the excellent illustrations, six photographs in colour and 67 black-and-white, which, derived from a wide variety of sources, add greatly to the interest and value of the book.

A few minor errors have been noted—page 4, "Camaroons" for "Cameroons"; page 6, "1943" should be "1953"; p. 70 DDT is not "Dichloro-diphenyl-trichloroacetic acid"; on page 138 "aninone" should read "quinone". These are unimportant matters which can be corrected in a later edition which will undoubtedly be called for. There is taking place in East Africa considerable expansion of tea growing; those engaged in the field on the new enterprises often face new problems and difficulties. Even comparatively experienced planters from India or Ceylon may previously have had to do little in the way of a new clearing and planting, and will welcome the assistance of Dr. Eden's book, which can be strongly recommended.

R. C.

REVIEWS IN BRIEF

Forestry Equipment Notes obtainable from the Food and Agriculture Organization, Rome.

A. 9-57—Motorized Tree Planter.

A.10-58—Homemade Dendrometers.

A.11-58—The Lignometer.

B.12-57—Gasoline Engine Driven Drilling Equipment, Type 60/S4.

B.13-57—Collapsible Fuel Storage Tanks.

B.14-57—BMCO Rock Buster.

B.15-57—The Albee Rolligon.

B.16-58—Mobile Camp Trailer.

C.22-57—Mobile Generator.

C.23-57—The Danarm Falcon Winch.

C.24-57—"Clowez" Light Dumper.

C.25-57—Tree Limbing Machine.

C.26-57—A Safer Method of Directional Felling Control with the Chain Saw.

D.18-57—An Accounting System for Mechanical and Motorized Equipment.

D.19-58—Meadows Mobile Saw Mill.

E.12-57—"Firebrake". A new composition for use against forest fires.

Survey of Activities 1957-58 by the General Manager, Shell Co. of East Africa Ltd., P.O. Box 30142, Nairobi.

This is the second survey of the activities of Shell and BP Companies in East Africa, and it includes a brief summary of the international oil scene as well as descriptions of the work in exploration, marketing, developments in distribution, capital investment, and Shell's Mombasa refinery project.

Soil and Land-use Surveys by the Regional Research Centre of the British Caribbean. Obtainable from the Imperial College of Tropical Agriculture, Trinidad, B.W.I.

1. Jamaica: Parish of St. Catherine, by K. C. Vernon, March 1958, price 20*s*.
2. British Guiana: The Rupununi Savannas, by R. F. Loxton, G. K. Rutherford, and J. Spector, March 1958, price 15*s*.

These reports contain summaries of the climate, geology, ecology, and agricultural practices, detailed descriptions of the soil genesis and profile characteristics, soil classification, land use, physical properties, and, for the British Guiana soils, trace element status and microbiological analyses.

REPORT FOR THE 1956/57 SEASON, Coffee Research and Experimental Station. Lyamungu, Moshi, Tanganyika.

This annual report of the coffee research branch of the Department of Agriculture, Tanganyika is obtainable from the Station.

FLORA OF TROPICAL EAST AFRICA. Obtainable from the Crown Agents for Oversea Governments, 4 Millbank, London, S.W.1. Cornaceae by B. Verdcourt, September 1958, price 1*s*. 6*d*. Caricaceae by J. H. Hemsley, October, 1958, price 1*s*. 6*d*. Primulaceae by P. Taylor, October, 1958, price 2*s*. 6*d*.

BARN CONSTRUCTION AND CURING PROCEDURE, Bulletin No. 7 of the Tobacco Research Board of Rhodesia and Nyasaland, July, 1958. Obtainable from the Secretary, P.O. Box 1909, Salisbury, Rhodesia.

The section on barn construction is illustrated by nine diagrams, with an explanatory text, and the section on curing procedure summarizes the important points in treating the leaf in the barn.

THE STATE OF FOOD AND AGRICULTURE, 1958, published by the Food and Agriculture Organization, Rome, pp. 222, price 12*s*. 6*d*. or U.S. $2.50.

This annual report gives special attention to a comparison of the situation in the economically more developed and less developed parts of the world. Chapter III consists of a special regional study of food and agricultural developments in Africa South of the Sahara.

THE AUGER HOLE METHOD, a field measurement of the hydraulic conductivity of the soil below the water table, by W. F. J. van Beers. Bulletin No. 1 of the International Institute for Land Reclamation and Improvement, Wageningen, Holland, 1958. pp. 32 plus 4 graphs in pocket, price 4*s*. 3*d*.

The general principle is that a hole is bored into the soil to a certain depth below the water table. When equilibrium is reached with the surrounding groundwater, a part of the water in the hole is removed. The water seeps into the hole again, and the rate at which it rises is measured and converted by a formula into the hydraulic conductivity (k) for the soil.

EXPERIMENTS IN PROGRESS NO. 10. Annual Report for 1956-57 of the Grassland Research Institute, Hurley, Berkshire, England, published by the Institute, 1958, pp. 110, price 7*s*. 6*d*.

The main body of this Report consists of progress reports of the seven departments, but in addition there are five original papers on special aspects of the work.

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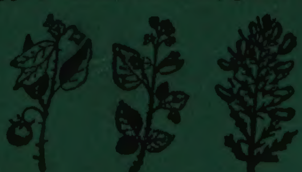

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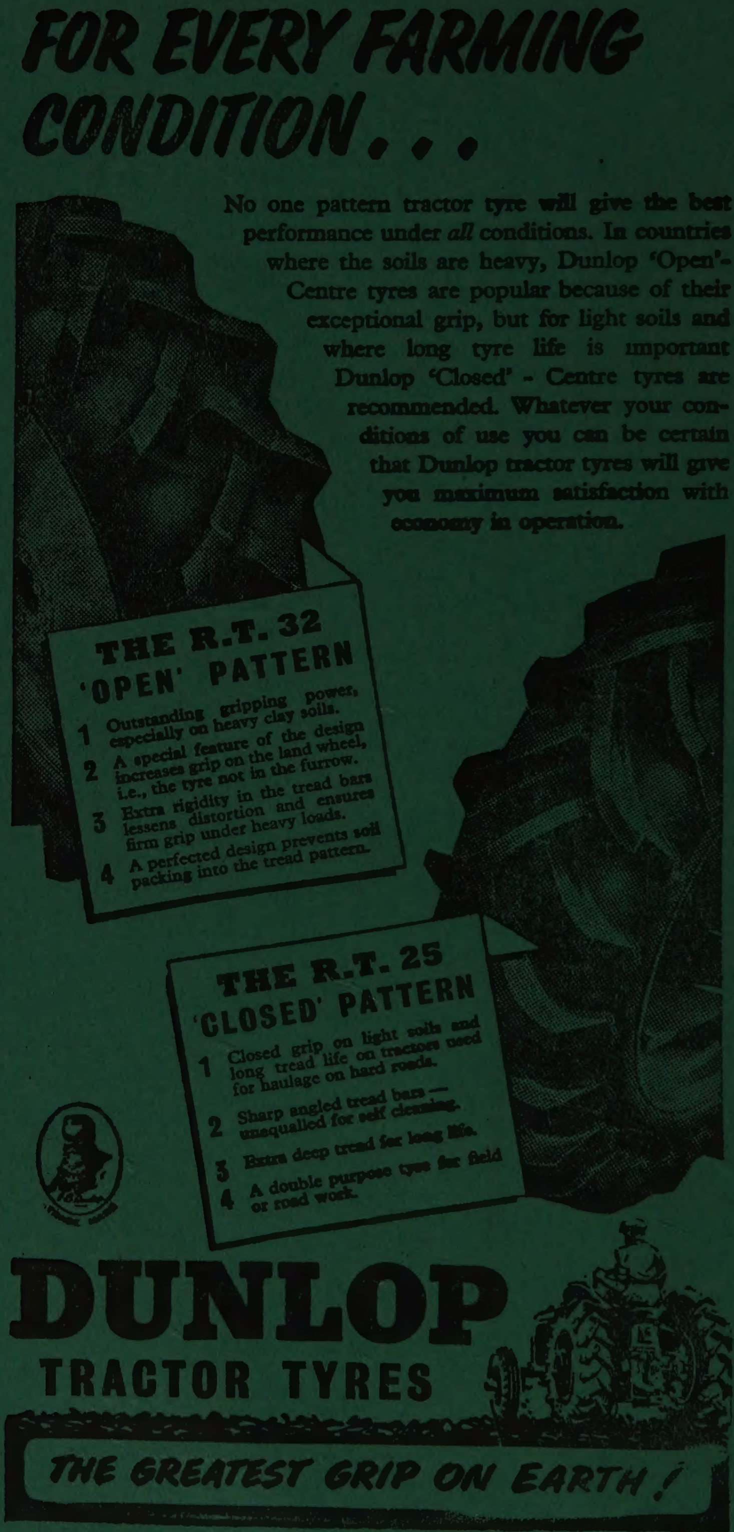

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